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This report provides abstracts for technical publications produced during 1995 by personnel of the Information Technology Division (ITD), one of the largest research and development collectives at the Naval Research Laboratory. The abstracts are organized into sections that represent the six branches with ITD: the Navy Center for Applied Research in Artificial Intelligence, Communications Systems, the Center for High Assurance Computer Systems, Transmission Technology, Advanced Information Technology, and the Center for Computational Science. Within each section, a list of branch papers published in 1993 and 1994 has also been included; abstracts for these papers may be found in prior-year editions of this report. Information on obtaining a copy of one or more of the abstracted orlisted publications is provided as well.

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INFORMATION TECHNOLOGY DIVISION
TECHNICAL PAPER ABSTRACTS 1995

I. INTRODUCTION

The Naval Research Laboratory (NRL) is the corporate laboratory for the United States Navy, and employs more than 3,700 civilians to conduct research and development programs in a wide range of technical disciplines. While more than 750 of NRL's employees hold doctorates, all members of the research staff participate extensively in national and international technical groups. In order to inform the research, academic, and industrial communities of its research activities, NRL annually publishes in excess of 1,000 journal articles, technical papers and reports.

The Information Technology Division (ITD) is one of the largest research and development collectives at NRL. ITD employs more than 220 civilian researchers organized into six branches: the Navy Center for Applied Research in Artificial Intelligence, Communication Systems, the Center for High Assurance Computer Systems, Transmission Technology, Advanced Information Technology, and the Center for Computational Science. The technical areas of expertise in ITD include:

ARTIFICIAL INTELLIGENCE
intelligent simulation
adaptive control software
machine learning methods
robotic vision and control
interactive systems
intelligent decision aids
reasoning under uncertainty

COMMUNICATIONS
network simulation
HF communications
communication security(COMSEC)
communications networking

HUMAN-COMPUTER INTERACTION
visualization techniques
metrics and evaluation
speech communication systems
human-computer dialogue

SOFTWARE
computer security (COMPUSEC)
network security
software assurance
software specification methodology
hard real time (HRT) computing
adaptive software testing methods
information security (INFOSEC)

DECISION SUPPORT SYSTEMS
parallel processing techniques
prototyping techniques
distributed decision support
distributed simulation

This report provides abstracts for technical publications produced by ITD personnel during 1995. The abstracts are organized into sections by ITD branch. Within each section, a list of papers published in 1993 and 1994, giving ITD report number, title, and author(s), has also been included; abstracts for these papers may be found in prior-year editions of this report.

To obtain a copy of one or more of the abstracted or listed papers, contact the Navy Center for Applied Research in Artificial Intelligence (NCARAI) librarian at 202-767-0018 (telephone); 202-767-3172 (fax); library@aic.nrl.navy.mil (email); or by postal mail at:
> Naval Research Laboratory
> Attn: NCARAI Library, Code 5510
> Washington, DC 20375-5337

Please give the report number, title, and author(s) of each paper desired. Additionally, the list of abstracts and a number of the papers (primarily those produced by NCARAI) are available through the WWW at URL:http://www.aic.nrl.navy.mil/papers, or by anonymous FTP to host ftp.aic.nrl.navy.mil(132.250.84.25), in the /pub/papers directory.

II. NAVY CENTER FOR APPLIED RESEARCH IN ARTIFICIAL INTELLIGENCE

CODE 5510

The Navy Center for Applied Research in Artificial Intelligence (NCARAI) is engaged in research and development efforts designed to address the application of artificial intelligence (AI) technology and techniques critical to Navy and national concerns. The emphasis at NCARAI is the linkage of theory and application in demonstration projects that use a full spectrum of AI methods.

The technical papers and reports generated by the NCARAI document the accomplishments of projects in computational reasoning for intelligent decision aids, intelligent M4 (multi-media, multi-modal) systems, interface design and evaluation, machine learning, and sensor-based systems. Innovative basic and exploratory research in these areas are made possible by NCARAI's staff, an impressive cross section of AI talent from the Government civilian and military sectors, visiting scholars from the academic communities, and consulting scientists from various industries. An ongoing seminar series, featuring notable scientists and scholars from around the country and from abroad, provides an excellent forum to exchange information and maintain awareness of current developments.

COMPUTATIONAL REASONING

Title: A Testbed for Experiments in Adaptive Memory Retrieval and Indexing
Author(s): Liwu Chang and Patrick R. Harrison
E-mail Address: liwu@aic.nrl.navy.mil or harrison@aic.nrl.navy.mil

Abstract

In this paper, we discuss properties of the Knack system which is designed as a testbed for experimenting with memory retrieval and organization in Case-Based Reasoning. Methods used for retrieval and indexing are based on mathematically sound techniques developed in classification, clustering and decision analysis. Retrieval is done using decision theoretic methods such as voting k-nearest neighbor and Bayesian theory with weighted attributes. New indices for cases are generated by using clustering methods. Cases are then re-organized using the new indices. The Knack environment was designed so that additional techniques and metrics can easily be added.

Title: VEG: Intelligent Workbench for Studying Earth's Vegetation
Author(s): Patrick R. Harrison, P. Ann Harrison, and Daniel S. Kimes
E-mail Address: harrison@aic.nrl.navy.mil

Abstract

The purpose of this paper is to describe VEG, an intelligent workbench for remote sensing scientists. VEG assists scientists in the analysis of optical reflectance data. VEG was designed to manage complexity, provide intelligent support, provide visualization tools, and contract the time required for a scientist studying the earth's vegetation to run exploratory studies, test alternative hypotheses, do what if thinking, and manage large data sets. VEG organizes and provides coherence to a diverse set of techniques and tools that are used by these scientists. It codifies in knowledge-based system components, heuristic knowledge used by these scientists when doing scientific work. The VEG system saves the scientist many hours of laborious calculation, and it empowers the scientist by allowing him or her to work quickly at a higher level of abstraction without the need to focus attention on a multitude of low-level tasks. The VEG system includes rule-based components, data management tools, technique design and management tools, browsers, graphics support, a highly visual interface, and a system for organizing and managing problem histories.

Title: Why Do Now What Can be Done Later?
Author(s): Scott Musman and Liwu Chang
E-mail Address: liwu@aic.nrl.navy.mil
Citation: Proceedings of Spatial-Temporal Reasoning Workshop held at IJCAI-95, Montreal, Quebec, Canada
Date: August 1995
Report No.: AIC-95-041

Abstract

Few AI systems attempt to weigh the benefit of acting immediately vs. waiting until additional information is gathered before a decision is made. We describe a probabilistic approach to making such determinations for an application of real-time weapon scheduling in the domain of Ship Self Defense. This is an example of a Decision Support System which must decide which actions to perform before all the evidence has been gathered. We describe a system suited to this application and how we augmented the basic design to include temporal models of the acquisition of evidence. We then show preliminary results illustrating how to use a probabilistic "impact" measure to assess the expected utility of putting off certain decisions. In our work we are interested in how the impact of evidence changes over time. In order to model this, we augment our belief networks to include a node which is used to represent time. We then condition evidence nodes to reflect the temporal interaction between the availability of the evidence and the decision to be made.

Title: Knack: An Adaptive CBR Tool for Experimenting with Retrieval and Indexing
Author(s): Liwu Chang, Patrick R. Harrison, and Laura Davis
E-mail Address: liwu@aic.nrl.navy.mil or harrison@aic.nrl.navy.mil
Citation: Internal Report
Date: November 1995
Report No.: AIC-95-042

Abstract

Knack is a testbed for experimenting with concepts of retrieval and indexing in Case Based Reasoning (CBR). Methods employed for retrieval and indexing are based on mathematically sound techniques developed in classification, clustering and decision analysis. Knack includes basic functions for specifying similarity, normalizing data and evaluation. Retrieval is done using both non-parametric (e.g., nearest neighbor) and parametric (i.e., Bayesian) statistical procedures with weighted attributes. New indices for cases are generated by using clustering methods. Cases are then organized using the new indices. We test the predictive accuracy of retrieval methods and the quality of indices generated in (re)-indexing. Knack includes adaptive functions to enhance performances of retrieval and indexing. Important functions of adaptation involve weighting and selecting attributes, learning dependency relationship and calculating typicality for each stored case. The Knack environment was designed so that additional techniques and metrics can easily be added.

Title: Mental Representations of Spatial Language
Author(s): Geoffrey S. Hubona, Stephanie S. Everett, Elaine Marsh, and
Kenneth Wauchope
E-mail Address: hubona@umbc.edu, severett@aic.nrl.navy.mil,
marsh@aic.nrl.navy.mil, or wauchope@aic.nrl.navy.mil
Citation: Internal Report
Date: March 1995
Report No.: AIC-95-018

Abstract

Previous studies have provided evidence of multi-level mental representations of language-conveyed spatial information. However, available evidence is largely inconsistent and inconclusive with regard to the structure of these mental representations. In this paper we will examine the theoretical issues raised by such studies and describe an upcoming experiment designed to investigate the nature of human mental representations formed by reading and listening to natural language descriptions of spatial information. The results of this experiment will resolve the contradictory findings of Taylor and Tversky (1992) of evidence for 'perspective-free' mental models and the findings of Perrig and Kintsch (1985) for 'perspective-biased' mental models.

Title: Conversational Dialogue in Graphical User Interfaces: Interaction
Technique Feedback and Dialogue Structure
Author(s): Manuel A. Pérez
E-mail Address: mperez@exodo.upr.clu.edu
Citation: Human Factors in Computing Systems, CHI '95 Conference
Proceedings Companion, Denver, CO.
Date: May 7-11, 1995
Report No.: AIC-95-021

Abstract

Human conversations have long been considered as a model for interaction with computers. One theory of human conversations, proposed by Clark and Schaefer, has already been used in other HCI efforts. In the work proposed here, another part of this theory, the states of understanding principles, is used as the basis for a model of feedback for graphical interaction techniques. A formal evaluation of the feedback model will be performed. The feedback model is extended to a multi-threaded dialogue model with which to handle interruption and cancellation requests as negotiated requests. The proposed dialogue model will serve as the requirement specification for the design of a dialogue controller in a user interface management system (UIMS). A prototype of this model will be built and a usability study will be conducted.

Title: Computational Pragmatics in HCI: Using Dialog Context in a MultiModal Interface

Author(s): Manuel A. Pérez

E-mail Address: mperez@exodo.upr.clu.edu

Abstract

This report describes a prototype built to explore the use of context representation in a multi-modal interface. The report focuses on the definition of new graphical interaction techniques that make use of context information for context-based interaction. This report describes the motivations for such techniques, and it presents some sample techniques and the natural language equivalents. The report finally describes a prototype that has been built to explore some of these issues.

INTERFACE DESIGN AND EVALUATION

Title: Extending the User Action Notation (UAN) for Specifying Interfaces with Multiple Input Devices and Parallel Path Structure

Author(s): Lynn Dievendorf, Derek Brock, and Robert J.K. Jacob
E-mail Address: brock@itd.nrl.navy.mil

Abstract

Many modern computer applications provide the user with a choice of several different methods of completing the same task. These options are afforded the user by the implementation of multiple input devices (e.g. a mouse and a keyboard) and keyboard shortcuts, or "hot-keys", into the interface. Although these options can be described by current interface specification methods, there is a need for a notation which can clearly represent this type of interface design in a meaningful format. A survey of formal specification methods was conducted in an attempt to identify one which captured these elements of the human-computer interface. The User Action Notation (UAN) showed promise for illustrating these options and providing an analytical technique capable of representing interfaces with this type of parallel structure. A graphing task from a DOS application called SigmaPlot was then specified in UAN. During this process, structural modifications to the standard UAN format were made and new symbols were added to the existing repertoire in an effort to augment the notation's analytical strengths. The modifications prove to clarify the specification of interfaces with multiple input devices and allow the reader of the specification to make meaningful comparisons of alternative methods for completing a specified task. These modifications are documented and their benefits are discussed.

Title: An Analysis of Communications and the Use of Military Terms in Navy Team Training

Author(s): Lisa B. Achille, Kay G. Schulze, and Astrid Schmidt-Nielsen
E-mail Address: achille@itd.nrl.navy.mil or schmidtn@aic.nrl.navy.mil

Abstract

Efficient communication is essential to effective team coordination. In particular, the use of specialized military terms with specific meaning is essential to accurate communications and also helps keep messages short. Internal Combat Information Center communications were recorded during Navy team training. Communication behavior was classified by speech turns, with emphasis on the use of military terms. Even though the purpose of military terms is to

promote brevity and accuracy, speech turns with military terms were wordier and had more format violations than did those without military terms. Military terms were used as officially defined only 57% of the time, and little change was found over training. Subjective comments made during debriefing sessions did not reflect actual measured behavior. The results suggest areas of communication behavior where specific training might be useful, including the accurate use of military terms.

Title: A Test of Speaker Recognition Using Human Listeners
Author(s): Astrid Schmidt-Nielsen
E-mail Address: schmidtn@aic.nrl.navy.mil
Citation: IEEE Speech Coding Workshop, Annapolis, MD
Date: September 1995
Report No.: AIC-95-011

Abstract

Speaker recognition for coders has only rarely been explicitly tested. We have developed a speaker recognition test based on SAME-DIFFERENT judgments for pairs of sentences spoken by either the same or different speakers. The test included 10 male and 10 female speakers. Scores were analyzed as a percentage of correct decisions, and using signal detection measures. Recognition results are reported for 10 coders at 2400 bits/s as well as for unprocessed speech and CELP.

Title: Extending the User Action Notation for Research in Individual Differences
Author(s): Derek Brock, Deborah Hix, Lynn Dievendorf, and J. Gregory Trafton
E-mail Address: brock@itd.nrl.navy.mil or trafton@itd.nrl.navy.mil
Citation: 1995 Human Factors and Ergonomics Society's 39th Annual Meeting in San Diego, CA
Date: October 9-13, 1995
Report No.: AIC-95-015

Abstract

Modern user interfaces frequently provide the user with more than one way to complete the same task, often through use of different input devices such as a mouse or keyboard. Research focused on individual differences in patterns of use and acquisition of skill in such interfaces led the authors to examine the strengths of the User Action Notation (UAN) as an analytical behavioral representation technique. This led to modifications to the standard UAN format that were made to augment the notation's capabilities. These modifications greatly clarify the specification of interfaces employing parallel interactive path structures, allowing the reader of the specification to make meaningful comparisons between functionally equivalent methods of task performance, and allowing researchers to empirically capture individual user strategies which can then be analyzed by correlating usage patterns with other cognitive measures. In this paper, these modifications are documented and their benefits discussed.

Title: A Paradigm to Assess and Evaluate Tools to Support the Software
   Development Process
Author(s): James. A. Ballas and Janet L. Stroup
E-mail Address: ballas@aic.nrl.navy.mil or stroup@itd.nrl.navy.mil
Citation: Naval Research Laboratory Formal Report, NRL/FR/5510--95-9766
Date: May 17, 1995
Report No.: AIC-95-019

Abstract

   The purpose of this research is to develop and evaluate software prototyping
tools that are used to produce "an executable unit that demonstrates particular
aspects of the behavior or functionality of the desired software product." It was
conducted with a particular perspective of assuming how the tools support an
aspect of software design that has received little attention: exploration of design
space. To pursue this perspective, an initial definition of design space exploration
was developed and hypotheses were proposed on what outcomes would be
observed if a tool supported design space exploration. Finally, techniques were
designed to obtain data to test the hypotheses in a general manner. Data were
collected with these techniques during a session in which a particular tool was
used to design software. The results provided some support for the hypotheses
and suggested options for further refinement of the methodology. The transcribed
observational data supported post-hoc analysis that revealed aspects of the
software development that occurred in the two-day session.

Title: Interpreting the Language of Informational Sound
Author(s): James. A. Ballas
E-mail Address: ballas@aic.nrl.navy.mil
Citation: Journal of the Washington Academy of Sciences, v83, n3, pp143-160,
   September 1993
Date: Released April, 1995
Report No.: AIC-95-020

Abstract

   Sound offers advantages for information systems, in the delivery of alerts,
duration information, for encoding of rapidly incoming information, for reaction
time enhancement, for background monitoring, and for representing position in 3-
D space around the person. To assist in utilizing these advantages, background
information on auditory capabilities and design guidelines are available. This
paper discusses ways of conveying information using non-speech audition,
including the limitations of present applications of auditory signals, the basis of
these limitation of present applications of auditory signals, the basis of these
limitations, recent developments in the field including encoding of urgency,
presenting a 3-D audio and using sounds of real events in computer systems. In
order to conceptualize the use of informational sound, analogies to language are
presented and described. While these analogies have clear limitations, they
provide a useful framework. Specifically, sounds are used analogously as

exclamations, for deictic reference both to place and to entities, as simile and metaphor, and for symbolic reference. The incorporation of everyday sound as symbols for computer processes is examined in detail. Issues in this application include the integration of the sound with a concurrent visual stimulus, and the identifiability of the sound. Recent research on causal ambiguity of everyday sounds is presented.

Title: Advanced Interaction for Command and Control Planning Systems
Author(s): Linda E. Sibert and James N. Templeman
E-mail Address: sibert@itd.nrl.navy.mil or templeman@itd.nrl.navy.mil
Citation: Proceedings of the First International Symposium on Command and
    Control Research and Technology, National Defense University, pp300-304
Date: June 1995
Report No.: AIC-95-032

Abstract

Providing natural, rapid, and convenient ways to register a person's interests and intentions to a command and control strike planning system speeds the planning process and allows planners to adapt more readily to changes in the tactical environment. The philosophy of our lab is to build interaction techniques that make greater use of a person's abilities and to validate new techniques within an application setting. We use an iterative, evolutionary design process that bases the refinement of an interaction technique on how well people use that technique on tasks adapted from real-world situations. We develop advanced interaction techniques that exploit the skills people already possess. Our results indicate that designs that take human sensory-motor skills and expectations into account make task completion more natural, easier, and less error prone.

Title: A Methodology for Developing New Interaction Techniques
Author(s): Deborah Hix, James N. Templeman, Ankush Gosain and Kapil
    Dandekar
E-mail Address: hix@itd.nrl.navy.mil or templeman@itd.nrl.navy.mil
Citation: HCI International Conference Proceedings
Date: July, 1995
Report No.: AIC-95-033

Abstract

We present a methodology for inventing, implementing, and evaluating new interaction techniques. We illustrate use of this methodology using examples of some of the more interesting issues we encountered in developing a new interaction technique for head-coupled panning and zooming, called pre-screen projection.

Title: Pre-screen Projection: From Concept to Testing of a New Interaction
   Technique
Author(s): Deborah Hix, James N. Templeman, and Robert J.K. Jacob
E-mail Address: hix@itd.nrl.navy.mil or templeman@itd.nrl.navy.mil
Citation: Human Factors in Computing Systems, CHI '95 Conference
   Proceedings Companion, Denver, CO.
Date: May 7-11, 1995
Report No.: AIC-95-034

Abstract

Pre-screen projection is a new interaction technique that allows a user to pan and zoom integrally through a scene simply by moving his or her head relative to the screen. The underlying concept is based on real-world visual perception, namely, the fact that a person's view changes as the head moves. Pre-screen projection tracks a user's head in three dimensions and alters the display on the screen relative to head position, giving a natural perspective effect in response to a user's head movements. Specifically, projection of a virtual scene is calculated as if the scene were in front of the screen. As a result, the visible scene displayed on the physical screen expands (zooms) dramatically as a user moves nearer. This is analogous to the real world, where the nearer an object is, the more rapidly it visually expands as a person moves toward it. Further, with pre-screen projection a user can navigate (pan and zoom) around a scene integrally, as one unified activity, rather than performing panning and zooming as separate tasks. This paper describes the technique, the real-world metaphor on which it is conceptually based, issues involved in iterative development of the technique, and our approach to its empirical evaluation in a realistic application testbed.

Title: Virtual Environment Firefighting / Ship Familiarization Feasibility Tests
   Aboard the EX-USS *Shadwell*
Author(s): David Tate, Linda E. Sibert, F. W. Williams, LCDR Tony King, and
   Donald H. Hewitt
E-mail Address: tate@ait.nrl.navy.mil or sibert@itd.nrl.navy.mil
Citation: Enclosure to NRL Ltr 3900 ser. 6180/0672.1, Report
   6180/0672A.1:FWW, Naval Research Laboratory
Date: October 17, 1995
Report No.: AIC-95-035

Abstract

Virtual environments (VE) is a term used to describe a three dimensional simulation environment that is generated by a computer, in which the user is allowed to interactively participate. Immersive VE is a term used when a special head-mounted display (HMD) is worn by the user so that he/she sees only the virtual world in which they are "immersed." Through appropriate modeling, simulation and graphics techniques, the user gets a sense of "presence" so that there is a sense of actually being "in" the simulated world. The Naval Research Laboratory is studying the potential for using immersive VE as a tool for shipboard firefighting training and mission rehearsal. Feasibility tests of the use

of VE for firefighter training were performed aboard the Naval Research Laboratory's full-scale fire research and test ship, the ex-USS *Shadwell,* during September 18-22, 1995. The objective of these tests was to demonstrate and measure the effectiveness of immersive VE as a training aid for firefighters aboard the ex-*Shadwell.* Portions of the *Shadwell* that were used in the tests are modeled in an immersive virtual environment with simulated smoke and fire. The tests were performed under realistic conditions with real shipboard fires, using Navy firefighting teams. This report describes the test procedure, presents preliminary results of those tests, and provides recommendations for future R&D efforts.

Abstract

A major limitation in understanding the perception of natural sound is the defined nature of the stimulus domain itself: a domain that immense in content, highly variable, and ephemeral. The variability of the domain will make it difficult to discover general principles. Studies by Ballas (1993) of a stimulus domain that was highly variable showed that many stimulus properties are unrelated to identification accuracy and speed. Interestingly, the only acoustic properties that were related to performance were the continued presence of harmonics and similar spectral bursts. These two properties reflect the spectral and temporal "entropy" in the sound.

One aspect of the stimulus domain that remains largely undocumented is the nature of different auditory environments. Examples of some of these environments demonstrate a high degree of variability in sound levels, content, and dynamic properties. One example is the data that has come from recent surveys of sound in outdoor and wilderness settings. The studies examined the characteristics of self produced noise—another phenomena that has been ignored in developing virtual environments. Self produced noise includes clothes rustling with movement, scratchy sounds with itching, and footsteps with walking. Acoustic recordings showed that self-noise, although highly variable, could be as high as 13dB above the ambient, high enough to provide a masking effect. The research also demonstrates that the acoustics of different outdoor environments are substantially different. For example, deserts and forests have different diurnal patterns.

Title: Navy Team Communications for Tactical Decision Making
Author(s): Lisa B. Achille and Kay G. Schulze
E-mail Address: achille@itd.nrl.navy.mil or schulze@scs.usna.navy.mil
Citation: Proceedings of the First International Symposium on Command and Control Research and Technology, National Defense University, pp277-287
Date: June 1995
Report No.: AIC-95-037

Abstract

Communications are a crucial aspect of military decision making. Team members in the Combat Information Center (CIC) share information through verbal communication, and computerized combat systems and displays. We recorded the internal CIC communications during Navy team training exercises and developed a classification scheme to categorize communication. Team communication included Resource Management, Situational Awareness, Metacognition, and Acknowledgments. With training, decision makers in large military teams streamlined resource management and increased acknowledgments. Patterns in the use of commands and metacognitive speech point out differences between the decision making processes of aircrews and large Navy teams. A team member's position in the hierarchical structure influenced his level of participation in the functional activities identified. The results suggest research areas to improve decision making in command and control systems, with potential implications for training.

Title: Toward Specification Techniques for Pre-Screen Projection and Other Next-Generation User Interfaces
Author(s): Robert J.K. Jacob, Principal Investigator and James N. Templeman, Scientific Officer
E-mail Address: templeman@itd.nrl.navy.mil
Citation: Final Technical Report, 594030-1
Date: September 25, 1995
Report No.: AIC-95-046

Abstract

We have investigated new languages for describing and implementing next-generation interfaces that might be used in 3-D visualization environments. Working with researchers at NRL Code 5513, we learned about the interfaces they are currently developing and are planning for future work. For current work we examined pre-screen projection and foot control; and we discussed future plans for research in 3-D manipulation, such as 3-D route planning and object-based 3-D visualization. We then studied how new specification languages might capture these types of interfaces and described an approach and conceptual model for doing this. We began with a model and language that combines discrete and continuous interactions, which is described in detail in this report. In collaboration with NRL researchers, we considered its applicability to NRL's 3-D user interface designs. We also began exploring the issue of how to connect the user interface component to a simulation component of a 3-D visualization system.

Abstract

How do people make decisions given contradictory information? This paper presents a model of how expert DSOs (defensive system operators) on a B1 bomber examine a complex series of signals, categorize whether those signals are dangerous or not, and then make a decision on the basis of those signals. This decision is made more difficult because an automatic on-board computer sometimes identifies the signal incorrectly. Therefore, the DSO must compare the actual signal to the system ID "guess". The proposed model is a hybrid model, combining a standard neural network and ACT-R, a production system, which achieves a high degree of success.

MACHINE LEARNING

Title: Stratified Case-Based Reasoning: Reusing Hierarchical Problem Solving
Episodes
Author(s): L. Karl Branting and David W. Aha
E-mail Address: aha@aic.nrl.navy.mil or karl@eolus.uwyo.edu
Citation: Proceedings of the Fourteenth International Joint Conference on
Artificial Intelligence (IJCAI-95), pp384-390, Montreal, Canada: Morgan
Kaufmann
Date: August 1995
AIC Report No.: AIC-95-001

Abstract

Stratified case-based reasoning is a technique in which abstract solutions
produced during hierarchical problem solving are used to assist case-based
retrieval, matching, and adaptation. We describe the motivation for the
integration of case-based reasoning with hierarchical problem solving, exemplify
its benefits, detail a set of algorithms that implement our approach, and present
their comparative empirical evaluation on a path planning task. Our results show
that stratified case-based reasoning significantly decreases the computational
expense required to retrieve, match, and adapt cases, leading to performance
superior both to simple case-based reasoning and to hierarchical problem
solving.

Title: An Implementation and Experiment with the Nested Generalized
Exemplars Algorithm
Author(s): David W. Aha
E-mail Address: aha@aic.nrl.navy.mil
Citation: Internal Report
Date: January 19, 1995
AIC Report No.: AIC-95-003

Abstract

This NRL NCARAI technical note (AIC-95-003) describes work with
Salzberg's (1991) NGE. I recently implemented this algorithm and have run a few
case studies. The purpose of this note is to publicize this implementation and
note a curious result while using it.

Title: For Every Generalization Action, Is There Really an Equal and Opposite Reaction? Analysis of the Conservation Law for Generalization Performance
Author(s): R. Bharat Rao, Diana Gordon, and William Spears
E-mail Address: gordon@aic.nrl.navy.mil
Citation: The XII International Conference on Machine Learning, Tahoe City, CA, Morgan Kaufmann Publishers, pp471-479
Date: July 9-12, 1995
AIC Report No.: AIC-95-004

Abstract

The "Conservation Law for Generalization Performance" [Schaffer, 1994] states that for any learning algorithm and bias, "generalization is a zero-sum enterprise." In this paper we study the law and show that while the law is true, the manner in which the Conservation Law adds up generalization performance over all target concepts, without regard to the probability with which each concept occurs, is relevant only in a uniformly random universe. We then introduce a more meaningful measure of generalization, expected generalization performance. Unlike the Conservation Law's measure of generalization performance (which is, in essence, defined to be zero), expected generalization performance is conserved only when certain symmetric properties hold in our universe. There is no reason to believe, a priori, that such symmetries exist; learning algorithms may well exhibit non-zero (expected) generalization performance.

Title: Unsupervised Classification Procedures Applied to Cloud Data
Author(s): Diana Gordon, Paul Tag, and Richard Bankert
E-mail Address: gordon@aic.nrl.navy.mil
Citation: Internal Report
Date: January 1995
AIC Report No.: AIC-95-005

Abstract

Machine learning algorithms can be subdivided into two types, supervised and unsupervised. Supervised learning is the more useful technique when the data samples have known outcomes that the user wants to predict. On the other hand, unsupervised learning is more appropriate when the user does not know the subdivisions into which the data samples, using relevant predictor features, should be divided. Prior categorical division may not be obvious because the problem may be a new one, for which the user has little experience. In such a case, an unsupervised learning procedure can provide insight into groupings that may make physical sense and facilitate future analysis. In this report, we explore the potential of two unsupervised learning programs, AutoClass and K-Means, when applied to a data set that was developed from satellite imagery of cloud regions that were expertly labeled into ten classes. Because cloud types hold meteorological significance, an automated classification from satellite imagery is of obvious use. We compare cloud classes produced by these systems with traditional cloud classes.

Title: Evaluation and Selection of Biases for Machine Learning

Author(s): Diana Gordon and Marie des Jardins
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Abstract

In this introduction, we define the term "bias" as it is used in machine learning systems. We motivate the importance of automated methods for evaluating and selecting biases using a framework of bias selection as search in bias and meta-bias spaces. Recent research in the field of machine learning bias is summarized.

Title: Genetic Algorithms for Expert System Validation

Author(s): Edward A. Roache, Kenneth A. Hickok, Kenneth F. Loje, Michael W. Hunt, and John J. Grefenstette
E-mail Address: gref@aic.nrl.navy.mil

Abstract

Modern power plants, as well as other process control environments, are using advisory and control software programs employing expert systems. The validation of the knowledge representation in these expert systems is critical to their success. Most expert systems currently deployed have been validated by certifying that the expert system provides appropriate conclusions for specific test cases. Exhaustive testing is not typically performed due to the complexity of the knowledge representation and the combinatorial problems associated with checking all possible inputs through all possible execution paths. This paper discusses a project, sponsored by the Electric Power Research Institute (EPRI), that examines an approach using genetic algorithms to efficiently identify cases where an expert system's response has a negative effect on the performance of the environment in which it is to operate. The purpose of the project is to test the hypothesis that genetic algorithms are useful in the validation of expert systems. The project status is reported.

Title: A Coevolutionary Approach to Learning Sequential Decision Rules
Author(s): Mitchell A. Potter, Kenneth A. De Jong, and John J. Grefenstette
E-mail Address: mpotter@aic.nrl.navy.mil or dejong@aic.nrl.navy.mil or
   gref@aic.nrl.navy.mil
Citation: Sixth International Conference on Genetic Algorithms (ICGA '95),
   University of Pittsburgh, Larry J. Eshelman, editor, pp366-372, Morgan
   Kaufmann Publishers, Inc.
Date: July 15-19, 1995
Report No.: AIC-95-010

Abstract

We present a coevolutionary approach to learning sequential decision rules
which appears to have a number of advantages over non-coevolutionary
approaches. The coevolutionary approach encourages the formation of stable
niches representing simpler subbehaviors. The evolutionary direction of each
subbehavior can be controlled independently, providing an alternative to evolving
complex behavior using intermediate training steps. Results are presented
showing a significant learning rate speedup over a non-coevolutionary approach
in a simulated robot domain. In addition, the results suggest the coevolutionary
approach may lead to emergent problems.

Title: Adaption of Knowledge for Reuse
Author(s): David W. Aha, editor
E-mail Address: aha@aic.nrl.navy.mil
Citation: A 1995 AAAI Fall Symposium Working Notes
Date: November 10-12, 1995
Report No.: AIC-95-012

Abstract

Several areas in AI address issues of creating and storing knowledge
constructs (such as cases, plans, designs, specifications, concepts, domain
theories, schedules). There is broad interest in reusing these constructs in similar
problem-solving situations so as to avoid expensive re-derivation. Adaptation
techniques have been developed to support reuse in frameworks such as
analogical problem solving, case-based reasoning, problem reformulation, or
representation change and task domains such as creativity, design, planning,
program transformation or software reuse, schedule revision, and theory revision.
However, many open issues remain, and progress on such issues as case
adaptation would substantially assist many researchers and practitioners. Our
goals are to characterize the approaches to adaptation employed in various AI
subfields, define the core issues in adaptation of knowledge, and advance the
state-of-the-art in addressing these issues. We intend that presentations will
investigate novel solutions to unsolved problems on adaptation, reflect diverse
viewpoints, and focus on adaptation issues that are common to several subfields
of AI. Discussions will be held on the strengths and limitations of adaptation
techniques and their interrelationships.

Title: Virtual Genetic Algorithms: First Results
Author(s): John Grefenstette
E-mail Address: gref@aic.nrl.navy.mil
Citation: Internal Report
Date: February 16, 1995
Report No.: AIC-95-013

Abstract

An important goal of the theory of genetic algorithms is to build models that predict how well genetic algorithms are expected to perform on a given "fitness landscape" (i.e., a given combination of representation, fitness function, and set of genetic operators). This paper describes the design of a software tool called a "virtual genetic algorithm" (VGA) that predicts the behavior of a genetic algorithm. The VGA operates like a genetic algorithm except that evaluations of individuals are based on empirically derived statistical fitness models. Because it by-passes the evaluation process, the VGA can be executed in a fraction of the time of the GA that it models, allowing multiple exploratory runs that produce average-case, best-case and worst-case predictions. We discuss ways to build the required models based on a preliminary exploration of the fitness landscape. Our initial results show that the VGA can provide a cost effective way to explore the likely performance of alternative genetic representations and operators.

Title: Robot Learning with Parallel Genetic Algorithms on Networked Computers
Author(s): John Grefenstette
E-mail Address: gref@aic.nrl.navy.mil
Citation: Proceedings of the 1995 Summer Computer Simulation Conference
   (SCSC '95), Ottawa, Ontario, Canada, 24-26 July, 1995
Date: March 21, 1995
Report No.: AIC-95-014

Abstract

This work explores the use of machine learning methods for extracting knowledge from simulations of complex systems. In particular, we use genetic algorithms to learn rule-based strategies used by autonomous robots. The evaluation of a given strategy may require several executions of a simulation to produce a meaningful estimate of the quality of the strategy. As a consequence, the evaluation of a single individual in the genetic algorithm requires a fairly substantial amount of computation. Such a system suggests the sort of large-grained parallelism that is available on a network of workstations. We describe an implementation of a parallel genetic algorithm, and present case studies of the resulting speedup on two robot learning tasks.

Title: Evolving Complex Structures via Cooperative Coevolution
Author(s): Kenneth A. De Jong and Mitchell A. Potter
E-mail Address: dejong@aic.nrl.navy.mil or mpotter@aic.nr.navy.mil
Citation: Proceedings of the Fourth Annual Conference on Evolutionary Programming, San Diego, CA
Date: March 1-3, 1995
Report No.: AIC-95-016

Abstract

A cooperative coevolutionary approach to learning complex structures is presented which, although preliminary in nature, appears to have a number of advantages over non-coevolutionary approaches. The cooperative coevolutionary approach encourages the parallel evolution of substructures which interact in useful ways to form more complex higher level structures. The architecture is designed to be general enough to permit the inclusion, if appropriate, of a priori knowledge in the form of initial biases towards particular kinds of decompositions. A brief summary of initial results obtained from testing this architecture in several problem domains is presented which shows a significant speedup over more traditional non-coevolutionary approaches.

Title: Evolving Neural Networks with Collaborative Species
Author(s): Mitchell A. Potter and Kenneth A. De Jong
E-mail Address: mpotter@aic.nr.navy.mil or dejong@aic.nrl.navy.mil
Citation: Proceedings of the 1995 Summer Computer Simulation Conference, Ottawa, Ontario, Canada
Date: July 24-26, 1995
Report No.: AIC-95-017

Abstract

We present a coevolutionary architecture for solving decomposable problems and apply it to the evolution of artificial neural networks. Although this work is preliminary in nature it has a number of advantages over non-coevolutionary approaches. The coevolutionary approach utilizes a divide-and-conquer technique in which species representing simpler subtasks are evolved in separate instances of a genetic algorithm executing in parallel. Collaborations among the species are formed representing complete solutions. Species are created dynamically as needed. Results are presented in which the coevolutionary architecture produces higher quality solutions in fewer evolutionary trials when compared with an alternative non-coevolutionary approach on the problem of evolving cascade networks for parity computation.

Title: Applying Genetic Algorithms to the Testing of Intelligent Controllers
Author(s): Alan C. Schultz, John J. Grefenstette, and Kenneth A. De Jong

E-mail Address: schultz@aic.nrl.navy.mil, gref@aic.nrl.navy.mil or dejong@aic.nrl.navy.mil

Abstract

Autonomous vehicles require sophisticated software controllers to maintain vehicle performance in the presence of vehicle faults. The test and evaluation of complex software controllers is a challenging task. The goal of this effort is to apply machine learning techniques to the general problem of evaluating an intelligent controller for an autonomous vehicle. The approach involves subjecting a controller to an adaptively chosen set of fault scenarios within a vehicle simulator, and searching for combinations of faults that produce noteworthy performance by the vehicle controller. The search employs a genetic algorithm. The evidence suggests that this approach is an effective supplement to manual and other forms of automated testing of sophisticated software controllers. Several intelligent controllers were tested in this project using several different genetic algorithm-based learning programs. Over the course of this research, the representation, evaluation function, genetic operators and the basic algorithm themselves evolved. This paper presents this work from the point of view of describing the process that the authors followed in applying these learning algorithms to this real-world problem.

Title: Working Notes for "Applying Machine Learning in Practice"
Author(s): David W. Aha, editor

E-mail Address: aha@aic.nrl.navy.mil

Abstract

The Workshop on *Applying Machine Learning in Practice* was held immediately prior to the Twelfth International Machine Learning Conference in Tahoe City, California, on 9 July 1995. This workshop focused on *characterizing the expertise* used by machine learning (ML) experts during the course of applying learning algorithms to practical applications. Several previous efforts have focused (at least in part) on ML applications.

Title: Weighting Features
Author(s): Dietrich Wettschereck and David W. Aha
E-mail Address: aha@aic.nrl.navy.mil
Citation: First International Conference on Case-Based Reasoning (ICCBR-95), Sesimbra, Portugal: Springer-Verlag.
Date: November 1995
Report No.: AIC-95-026

Abstract

Many case-based reasoning algorithms retrieve cases using a derivative of the k-nearest neighbor (kNN) classifier, whose similarity function is sensitive to irrelevant, interacting, and noisy features. Many proposed methods for reducing this sensitivity parameterize kNN's similarity function with feature weights. We focus on methods that automatically assign weight settings using little or no domain-specific knowledge. Our goal is to predict the relative capabilities of these methods for specific dataset characteristics. We introduce a five-dimensional framework that categorizes automated weight-setting methods, empirically compare methods along one of these dimensions, summarize our results with four hypotheses, and describe additional evidence that supports them. Our investigation revealed that most methods correctly assign low weights to completely irrelevant features, and methods that use performance feedback demonstrate three advantages over other methods (i.e., they require less pre-processing, better tolerate interacting features, and increase learning rate).

Title: Learning to Break Things: Adaptive Testing of Intelligent Controllers
Author(s): Alan C. Schultz, John J. Grefenstette, and Kenneth A. De Jong
E-mail Address: schultz@aic.nrl.navy.mil
Citation: To appear in Handbook of Evolutionary Computation, Chapter, G3:5, IOP Publishing Ltd. and Oxford University Press (1997)
Date: 1995
Report No.: AIC-95-027 [see also: AIC-95-022]

Abstract

Autonomous vehicles require sophisticated software controllers to maintain vehicle performance in the presence of vehicle faults. The test and evaluation of complex software controllers is a challenging task. The goal of this effort is to apply machine learning techniques to the general problem of evaluating an intelligent controller for an autonomous vehicle. The approach involves subjecting a controller to an adaptively chosen set of fault scenarios within a vehicle simulator, and searching for combinations of faults that produce noteworthy performance by the vehicle controller. The search employs a genetic algorithm. The evidence suggests that this approach is an effective supplement to manual and other forms of automated testing of sophisticated software controllers. Several intelligent controllers were tested in this project using several different genetic algorithm-based learning programs. Over the course of this research, the representation, evaluation function, genetic operators and the basic algorithm themselves evolved. This section presents this work from the point of view of describing the process that the authors followed in applying these learning algorithms to this real-world problem.

Title: Adapting Crossover in Evolutionary Algorithms
Author(s): William M. Spears
E-mail Address: spears@aic.nrl.navy.mil
Citation: Evolutionary Programming IV, John R. McDonnell, Robert G.
  Reynolds, and David B. Fogel, editors, pp367-384
Date: February 1995
Report No.: AIC-95-043

Abstract

One of the issues in evolutionary algorithms (EAs) is the relative importance of two genetic operators: mutation and crossover. Genetic algorithms (GAs) and genetic programming (GP) stress the role of crossover, while evolutionary programming (EP) and evolution strategies (ESs) stress the role of mutation. The existence of many different forms of crossover further complicates the issue. Despite theoretical analysis, it appears to be difficult to decide a priori which form of crossover to use, or even if crossover should be used at all, for a given problem. One possible solution to this difficulty is to have the EA be self-adaptive, i.e., to have the EA decide which forms of crossover to use and how often to use them, as the EA attempts to solve the problem. In this paper we describe two adaptive mechanisms for controlling the use of crossover in an EA. The first mechanism assumes that crossover will be used, and chooses between two different forms. The second mechanism is more flexible in that it can also choose to not use crossover. We explore the behavior of both mechanisms in a number of different situations. Finally, we present an improvement to the adaptive mechanisms. Surprisingly this improvement can also be used to enhance performance in a non-self-adaptive EA.

Title: Recombination Parameters
Author(s): William M. Spears
E-mail Address: spears@aic.nrl.navy.mil
Citation: Internal Report
Date: October 1995
Report No.: AIC-95-044

Abstract

One operator that is often used in evolution strategies, genetic algorithms, and genetic programming is recombination, where material from two (or more) parents is used to create new offspring. There are numerous ways to implement recombination. However, all share a common motivation – that potentially useful solutions to a problem can be constructed from smaller components (often called

"building blocks"). This section gives an overview of some of the motivation, issues, theory, and heuristics for recombination.

Title: Evolving Fuzzy Logic Control Strategies using SAMUEL: An Initial
  Implementation
Author(s): Helen Cobb and John J. Grefenstette
E-mail Address: gref@aic.nrl.navy.mil
Citation: Internal Report
Date: November 1995
Report No.: AIC-95-045

Abstract

This report describes initial results using the SAMUEL learning system to
evolve fuzzy logic control rules. The implementation of fuzzy control rules is
described, along with the integration of the fuzzy logic representation with the
learning methods in SAMUEL. Initial results are described on sample learning
tasks in which SAMUEL evolves fuzzy control rules for a simulated evasion task.
Future enhancements are also described.

Title: Explicitly Biased Generalization
Author(s): Diana Gordon and Donald Perlis
E-mail Address: gordon@aic.nrl.navy.mil
Citation: In Goal-Driven Learning (A. Ram and D. Leake, pubs.), pp321-354
Date: 1995
Report No.: AIC-95-047

Abstract

During incremental concept learning from examples, tentative hypotheses are
formed and then modified to form new hypotheses. When there is a choice
among hypotheses, "bias" is used to express a preference. Bias may be
expressed by the choice of hypothesis language, it may be implemented as an
evaluation function for selecting among hypotheses already generated, or it may
consist of screening potential hypotheses prior to hypothesis generation. This
paper describes a use of the third method. Bias is represented explicitly both as
assumptions that reduce the space of potential hypotheses and as procedures
for testing these assumptions. There are advantages gained by using explicit
assumptions. One advantage is that the assumptions are meta-level hypotheses
that are used to generate future, as well as to select between current, inductive
hypotheses. By testing these meta-level hypotheses, a system gains the power
to anticipate the form of future hypotheses. Furthermore, rigorous testing of these
meta-level hypotheses before using them to generate inductive hypotheses
avoids consistency checks of the inductive hypotheses. A second advantage of
using explicit assumptions is that bias can be tested using a variety of learning
methods.

Abstract

The increasing availability of parallel computing architectures provides an opportunity to exploit this power as we scale up evolutionary algorithms (EAs) to solve more complex problems. To effectively exploit fine grained parallel architectures, the control structure of an EA must be decentralized. This is difficult to achieve without also changing the semantics of the selection algorithm used, which in turn generally produces changes in an EA's problem solving behavior. In this paper we analyze the implications of various decentralized selection algorithms by studying the changes they produce on the characteristics of the selection pressure they induce on the entire population. This approach has resulted in significant insight into the importance of selection variance and local elitism in designing effective distributed selection algorithms.

SENSOR-BASED SYSTEMS

Title: Automatic Target Extraction in Infrared Images
Author(s): Behrooz Kamgar-Parsi
E-mail Address: kamgar@aic.nrl.navy.mil
Citation: 1995 NRL Review, Naval Research Laboratory Publication,
NRL/PU/5230--95-274, pp143-146
Date: May 1995
Report No.: AIC-95-009

Abstract

A fundamental problem in computer vision and image processing is image segmentation or object extraction in intensity or infrared images. Current techniques require either user-supplied parameters or model-based templates. The former is not automated and the latter is slow, crude (since the object pose in the image and the model pose in the template may not agree), and may not distinguish between two similar objects, e.g. two types of aircraft. In this paper we report the invention of a new image processing technique for object extraction in infrared images without the above shortcomings. This allows automated extraction from background of warm (or cold) objects which are often objects of interest in infrared images. The technique has a wide range of potential applications when analyzing infrared images both for projects of interest to the Navy, such as automatic target recognition and retargeting, and for commercial applications. In particular, we have developed software which extracts with remarkable clarity aircraft approaching a carrier in FLIR images. The software allows the development of an automated system for the recognition of the type of landing aircraft. This is desirable in situations when a carrier does not wish to communicate with the aircraft, and consequently the approaching aircraft must be recognized from its shape.

Title: Rejection of Unfamiliar Patterns with Multilayer Neural Networks
Author(s): Behrooz Kamgar-Parsi and Behzad Kamgar-Parsi
E-mail Address: kamgar@aic.nrl.navy.mil or behzad@ait.nrl.navy.mil
Citation: Applications and Science of Artificial Neural Networks, Steven K.
Rogers and Dennis W. Ruck, Chairs/Editors, SPIE Publication, v 2492, Part
One, pp490-504
Date: April 17, 1995
Report No.: AIC-95-025

Abstract

Most of the pattern recognition applications of multilayer neural networks have been concerned with classification and not rejection of a given pattern. For example, in character recognition all alphabetical characters must be recognized as one of the 26 characters, as there is nothing to reject. However, in many situations, there is no guarantee that all the patterns that will be presented to the network would actually belong to one of the classes on which the networks has

been trained,. In such cases, a useful network must be capable of rejection as well as classification. In this paper we propose a scheme to develop multilayer networks with rejection capabilities. The discriminating power of the proposed technique appears to be comparable to that of the human eye.

Title: Performance Evaluation of Navigation Algorithms Using Percolation Theory
Author(s): Ralph Hartley
E-mail Address: hartley@aic.nrl.navy.mil
Citation: Proceedings of the Third IASTED International Conference: Robotics and Manufacturing, R.V. Mayorga, editor, Cancún, Mexico, pp46-50
Date: June 14-16, 1995
Report No.: AIC-95-031

Abstract

Worst case analysis of algorithms for navigation through an unknown environment are not very informative. A well defined average case analysis would be much more useful. Percolation theory, a body of work from statistical physics, is applied to this problem. Percolation theory allows a meaningful definition of average case performance to be made. This definition is universal in that identification does not depend on details of the obstacles shape and local distribution.

Title: Distribution and Moments of the Weighted Sum of Uniform Random Variables with Applications In Reducing Monte Carlo Simulations
Author(s): Behzad Kamgar-Parsi, Behrooz Kamgar-Parsi and Menashe Brosh
E-mail Address: kamgar@aic.nrl.navy.mil or behzad@ait.nrl.navy.mil
Citation: Journal of Statistical Computation and Simulation, v52, pp399-414
Date: August 1995
Report No.: AIC-95-038

Abstract

We derive analytical expressions for the distribution function and the moments of the weighted sum $Y = \sum_{i=1}^{N} a_i X_i$ where X_i are independent random variables with non-identical uniform distributions, for an arbitrary number of variables N, and arbitrary coefficient values a_i. These results are the generalizations of those for the regular sum of uniform random variables. Using the results, we examine the inadequacy of the central limit approximation for finite N. We also discuss the savings in the cost of computing properties of the weighted sum using these results vs. Monte Carlo simulations. We give an example of the application of the weighted sum to analyzing the effects of digitization error in computer vision.

Title: Rejection with Multilayer Neural Networks: Automatic Generation of the Training Set
Author(s): Behrooz Kamgar-Parsi and Behzad Kamgar-Parsi
E-mail Address: kamgar@aic.nrl.navy.mil or behzad@ait.nrl.navy.mil
Citation: Proceedings of the World Congress on Neural Networks (WCNN'95), v2, pp174-177
Date: July 1995
Report No.: AIC-95-039

Abstract

In uncontrolled environments, there is no guarantee that all the patterns that will be presented to the network have been trained. In such cases, a useful network must be capable of rejection as well as classification. In this paper we propose a technique to develop multilayer networks with rejection capabilities. To facilitate this we have developed a random deformation technique capable of generating an arbitrarily large number of true and false look-alikes of a given class. The discriminating power of the proposed technique (in visual pattern recognition) appears to be comparable to that of the human eye.

Title: Coding and Compression with Flexible Transforms
Author(s): Behzad Kamgar-Parsi, Behrooz Kamgar-Parsi and Larry Schuette
E-mail Address: kamgar@aic.nrl.navy.mil or behzad@ait.nrl.navy.mil
Citation: Proceedings of the IASTED Conference on Signal and Image Processing, Las Vegas, NV, pp414-417
Date: November 1995
Report No.: AIC-95-040

Abstract

Flexible transforms represent the data in terms of a set of flexible basis functions, i.e. functions with adjustable parameters. These transforms are more powerful than fixed transforms in coding signals, nevertheless they are seldom used in practice. This is because the computation of a flexible transform involves solving a nonlinear optimization problem. In this paper, we suggest a recipe for computing flexible transforms. Flexible transforms and 2-layer neural networks are closely related. Computation of flexible transforms is equivalent to learning the signal with the network. We use the corresponding fixed transform to construct the network and initialize its weights. Empirical evidence suggests that this procedure yields optimum solutions.

Title: A Wide-field Triangulation Laser Rangefinder for Machine Vision
Author(s): Frank Pipitone and Thomas Marshall
E-mail Address: pipitone@aic.nrl.navy.mil
Citation: Selected Papers on Laser Distance Measurements, SPIE Milestone Series, vol. 115
Date: 1995
Report No.: AIC-95-048

Abstract

This paper describes the design, construction, and measured performance of an experimental scanning laser rangefinder. The instrument uses active triangulation and employs an optical bandpass filter to minimize the effects of ambient illumination. Its use of a single photodetecting element, a photomultiplier, is a unique feature among triangulation rangefinders. A novel scanning configuration based on spherical coordinates is employed, resulting in an extremely large field of view. Nearly 75% of the surrounding solid angle is accessible. Reasonably high speed and accuracy are obtained. The typical error in range at a range of 50 inches is 0.12 inches. The typical error in either of the two angular coordinates is 0.03 degrees. The maximum instantaneous rate of acquisition of range samples is 500 Hz. Much higher speed and accuracy appear achievable with various modifications and improvements. This type of rangefinder appears most useful in automatic surveillance and robot navigation applications because of its large field of view.

Title: Model-based Pattern Recognition with Multilayer Neural Networks: Learning From the Eye
Author(s): Behrooz Kamgar-Parsi and Behzad Kamgar-Parsi
E-mail Address: kamgar@aic.nrl.navy.mil or behzad@ait.nrl.navy.mil
Citation: Internal Report
Date: 1995
Report No.: AIC-95-051

Abstract:

We propose a model-based pattern recognition approach using multilayer neural networks to overcome certain shortcomings of the existing model-based techniques. In certain domains, the approach may allow the possibility of duplicating the discriminating power of the human eye in a network, provided that the pattern in question is meaningful to humans. To facilitate this we have developed a random deformation technique capable of generating an arbitrarily large number of true and false look-alikes of the model. The suggested approach attempts to construct decision boundaries at places where the human eye appears to "draw" the line between acceptable and unacceptable patterns. Application of this technique to a real life problem shows a performance comparable to that of the eye.

1994 PUBLICATIONS

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AIC-93-050 Using GAs for Concept Learning with Adaptive Bias, *K.A. DeJong, W.M. Spears, and D.F. Gordon*

III. COMMUNICATION SYSTEMS

CODE 5520

The Communication Systems (CS) Branch is the principal agent for communication system design, analysis, and engineering, with current efforts focused on strategic, tactical and special warfare areas. Emphasis is given to network design, system performance validation via computer simulation experiments, modulation and coding techniques, communication terminal design and development, advanced instrumentation techniques, and equipment development. The Branch also provides consultation and support to other components of NRL, Navy, SDIO, and DoD in the areas of secure communication equipment, systems design and development, and warfare architecture.

Title: Admission-Control Policies for Multihop Wireless Networks
Author(s): Craig M. Barnhart, Jeffrey E. Wieselthier, and Anthony Ephremides
E-mail Address: barnhart@itd.nrl.navy.mil
Citation: ACM Journal on Wireless Networks, v1, pp373-387
Date: December 1995
Report No.: CS-95-001

Abstract

In this paper, we investigate the admission-control problem for voice traffic in fixed-route circuit-switched wireless networks. We consider coordinate-convex admission-control policies and a "blocked-calls-cleared" mode of operation, in conjunction with the usual assumptions on the voice process statistics. These conditions result in a product-form stationary distribution for the voice state of the system, which facilitates the evaluation of network performance.

However, to determine the optimal policy a large state space must be searched. We develop a recursive procedure to accelerate the evaluation of a large number of different admission-control policies, and a descent-search method to reduce significantly the number of policies that must be evaluated in searching for the optimal one. The numerical examples we present indicate that reduced blocking probability (or increased throughput) can be obtained by administering active admission control. The degree of improvement is highest in moderately overloaded traffic conditions, but it is typically small in low-capacity networks (at all loads). However, in applications where the performance measure associates different revenues or costs with the various call types, considerable improvement can be obtained when admission control is used.

Title: Standard Clock Simulation and Ordinal Optimization Applied to Admission Control in Integrated Communication Networks
Author(s): J.E. Wieselthier, C.M. Barnhart and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Discrete Event Dynamic Systems: Theory and Applications, v5, pp243-280
Date: April/July 1995
Report No.: CS-95-002

Abstract

In this paper we apply the ideas of ordinal optimization and the technique of Standard Clock (SC) simulation to the voice-call admission-control problem in integrated voice/data multihop radio networks. This is an important problem in networking that is not amenable to exact analysis by means of the usual network modeling techniques. We first describe the use of the SC approach on sequential machines, and quantify the speedup in simulation time that is achieved by its use in a number of queueing examples. We then develop an efficient simulation model for wireless integrated networks based on the use of the SC approach, which permits the parallel simulation of a large number of admission-control policies, thereby reducing computation time significantly. This model is an

extension of the basic SC approach in that it incorporates fixed-length data packets, whereas SC simulation is normally limited to systems with exponentially distributed interevent times. Using this model, we demonstrate the effectiveness of ordinal-optimization techniques, which provide a remarkably good ranking of admission-control policies after relatively short simulation runs, thereby facilitating the rapid determination of good policies. Moreover, we demonstrate that the use of crude, inaccurate analytical and simulation models can provide highly accurate policy rankings that can be used in conjunction with ordinal-optimization methods, provided that they incorporate the key aspects of system operation.

Abstract

Multiple-access schemes are introduced and analyzed for the integration of voice and data traffic in packet radio networks using code-division multiple-access (CDMA). The multiple-access capability of the CDMA channel is used to accommodate several voice calls simultaneously, while the data users follow the ALOHA protocol with retransmission control and content for the remaining (if any) multiple-access capability of that channel. The retransmission probabilities implemented by the backlogged data users are updated based on estimates of data backlog and number of established voice calls; these estimates are obtained from the side information (feedback) about the state of channel activities. Retransmission schemes based on different feedback information are investigated.

A two-dimensional Markovian model is developed for the voice and data traffic, with the data backlog and number of established voice calls representing the state of the system. Based on this model, the voice-call blocking probability, the throughput of both traffic types, and the delay of the data packets are evaluated and the tradeoffs between the parameters of different traffic types are quantified. The voice/data integration schemes introduced achieve efficient movable-boundary channel access in the code (CDMA) domain.

Abstract

In this report we apply the ideas of ordinal optimization and the technique of Standard Clock (SC) simulation to the voice-call admission-control problem in integrated voice/data multihop radio networks. We first describe the use of the SC approach on sequential machines, and quantify the speedup in simulation time that is achieved by its use in a number of queueing examples. We then develop an efficient simulation model for wireless integrated networks based on the use of the SC approach, which permits the rapid parallel simulation of a large number of admission-control policies. We have extended the basic SC approach by incorporating fixed-length data packets, whereas SC simulation is normally limited to systems with exponential interevent times. Using this model, we demonstrate the effectiveness of ordinal-optimization techniques, which provide a remarkably good ranking of admission-control policies after relatively short simulation runs, thereby facilitating the rapid determination of good policies. Moreover, we demonstrate that the use of crude, inaccurate analytical and simulation models can provide highly accurate policy rankings that can be used in conjunction with ordinal-optimization methods, provided that they incorporate the key aspects of system operation.

Title: Voice Management and Multiplexing Protocols Developed for the Data and Voice Integration Advanced Technology Demonstration

Author(s): James P. Hauser

E-mail Address: hauser@itd.nrl.navy.mil

Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5521--95-7792

Date: November 1995

Report No.: CS-95-005

Abstract:

The Data and Voice Integration Advanced Technology Demonstration (ATD) is a four year program managed by the Naval Research Laboratory (NRL) with a goal of demonstrating integrated communication services using low bandwidth, tactical communication channels. At present, Phases I and II of a three phase demonstration have been completed. Phase I integrated real-time voice and non-real-time data services over a single link, low capacity tactical circuit. Phase II demonstrated these services over a tactical broadcast network. Phase III will demonstrate data/voice integration with inter networking and multicast routing capabilities. This report focuses on two of the major areas of development critical to the success of this ATD. The first area is the development of voice management protocols for half and full duplex operation. The second is the development of a Data/Voice Integrator (DVI). The DVI design includes a Subnetwork Provider Interface (SNPI), an interface to a Red Link controller (RLC), queue management, a multiplexing scheme, and a software design. The multiplexing protocol creates a unique form of "link-sharing," i.e., the ability to dynamically divert bandwidth that is reserved but not currently being used to support other services.

Title: Real-Time Network Packet Voice Support in the Data Voice Integration
Advanced Technology Demonstration
Author(s): Joseph P. Macker
E-mail Address: macker@itd.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report NRL/FR/5520--95-0015
Date: October 11, 1995
Report No.: CS-95-006

Abstract

This report describes the NRL design and development of a flexible, low data rate network voice terminal application and its use within the Data and Voice Integration Advanced Technology Demonstration (DVI ATD). The primary objective was to provide real-time interactive voice communications with highly efficient network bandwidth utilization. The operation and design of various related software subsystems are described in this document. In addition, this paper emphasizes how the application utilizes the resource reservation mechanism in the DVI ATD project to support voice integration over bandwidth-constrained wireless packet networks.

Title: Quality Assurance, Alignment, and Test Procedure for the MD-1310/U
Modulator
Author(s): J.A. Molnar and E.R. Farren
E-mail Address: molnar@itd.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/FR/5524--95-9796
Date: December 7. 1995
Report No.: CS-95-007

Abstract

The MD-1310/U VLF/LF Modulator manufacturing process includes test procedures to ensure specification compliance. Procedures include incoming inspection, alignment, verification testing, and temperature qualification. This report provides detailed instructions on the adjustment and testing of the MD-1310/U VLF/LF Modulator including test set-ups, adjustment location diagrams, and expected results. Detailed instructions on records to be kept during the execution of each step in the Quality Assurance process are provided. Appendix provides a complete set of sample data as a guideline in proper record keeping.

Title: Novel Techniques for the Analysis of Wireless Integrated Voice/Data
Networks
Author(s): Jeffrey E. Wieselthier, Craig M. Barnhart, and Anthony Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5521--95-7744
Date: July 24, 1995
Report No.: CS-95-008

Abstract

In this report we consider the evaluation of data-packet delay in wireless integrated voice/data networks. In networks that support circuit-switched voice, the voice occupancy process satisfies a product-form solution under reasonable modeling assumptions. Although this product-form solution provides an accurate characterization of equilibrium voice-traffic behavior, it does not directly provide a method to evaluate data-packet delay. However, examination of each link separately in a manner that incorporates interaction with the rest of the network permits us to take advantage of the wireless nature of the network and obtain a three-flow characterization of each link, which also satisfies a product-form solution and is hence termed a "mini-product-form" solution. By matching the values of these flows to the average values obtained from the product-form solution of the entire network, we obtain a three-dimensional Markov chain characterization of the voice occupancy state on the link, which permits a simpler evaluation of data-packet delay. A further reduction is possible by converting the three-dimensional chain to a single-dimensional one. Performance results demonstrate that these models provide satisfactory delay estimates that also appear to be upper bounds on delay.

Title: Integrated Computer Aided Design Practices as Demonstrated on A Fin-Line Device
Author(s): Joseph A. Molnar
E-mail Address: molnar@itd.nrl.navy.mil
Citation: Journal of the Institution of Electronics and Telecommunications Engineers, v41, n1, pp39-44
Date: January-February, 1995
Report No.: CS-95-009

Abstract

The integration of circuit simulation with numerical simulation of electromagnetic structures is examined in the application to fin-line attenuator design. Numerical modeling of the electromagnetic structure provides the benefit of visualizing the structure and examining the propagation of electromagnetic fields, an aspect that is absent from circuit simulation computer packages. Associated with the benefits is the ability to export design information to circuit simulators for improved computation efficiency. The disadvantage remains that numerical modeling of complex structures is computationally intensive.

Title: MD-1310/U VLF/LF Modulator Functionality and Performance Test Report
Author(s): T.H. Gattis
E-mail Address: gattis@itd.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5524--95-7763
Date: November 13, 1995
Report No.: CS-95-010

Abstract

The Naval Research Laboratory (NRL) has developed a new VLF/LF modulator (MD-1310/U) that provides modulation formats consistent with all present and projected fixed VLF/LF Fleet requirements. Prior to service introduction an extensive, three phase, testing program was performed. The methods, procedures and results of the three phases of testing are discussed. The first phase of testing was conducted at NRL and at NRTF, Annapolis, Maryland, on the Engineering Design Model (EDM). Upon successful completion of the EDM testing phase a Production Development Model (PDM) was authorized. The second phase of testing, a 90-day operational suitability test, was conducted at NRTF, Annapolis on two PDMs. During the operational suitability test both PDMs performed flawlessly and exhibited only minor variations from the modulator currently used, the MD-856. Production was authorized. The third phase of testing assures the signal quality and workmanship of each production modulator. This phase of testing is described as Quality Assurance (Q/A) Testing. The Q/A testing phase was completed in May 1995.

Title: Adding Training Capability to COTS Network Management Software
Author(s): Radhakrishnan R. Nair and Dennis N. McGregor
E-mail Address: nair@itd.nrl.navy.mil
Citation: Networld & Interop 1995
Date: March 1995
Report No.: CS-95-011

Abstract

Computer networks are growing larger day by day. The complexity in managing large networks of heterogeneous components is also growing. Network managers of the future need to be trained in solving interaction problems pertinent to such networks. Performing training in a real operational network would of course be disturbing to the users of the network, and small experimental networks which facilitate non-disruptive training do not in general have the capability to imitate the problems of real large-scale networks.

If the network management platform interfaces to a network simulation (in the same fashion it interfaces to the real network), new managers could be trained using the simulation without disrupting operations of the real network. Since simulations are easily re-configurable, realistic network problems could be synthesized, and the trainees could be given hands-on training with network management. This simulation could also be used as a network planning tool. In this paper we address the problems of interfacing a network simulation to a commercial off-the-shelf (COTS) network manager.

Title: Tactical Radio Frequency Requirements for Next Generation Internet Protocols
Author(s): Robert B. Adamson
E-mail Address: adamson@itd.nrl.navy.mil
Citation: Internet Protocol Next Generation
Date: October 1995
Report No.: CS-95-012

Abstract

This document was submitted to the IETF IPng area in response to RFC 1550. Publication of this document does not imply acceptance by the IPng area of any ideas expressed within. Comments should be submitted to the big-internet@munnari.oz.au mailing list.

Title: Coding and Synchronization Analysis of the NILE UHF Fixed-Frequency Waveform
Author(s): Paul J. Crepeau and John C. McCanless
E-mail Address: crepeau@itd.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5520--95-7776
Date: September 18, 1995
Report No.: CS-95-013

Abstract

The NILE UHF fixed-frequency waveform employs an RS (48, 30) error control code with 8-bit characters. The code is used both to correct errors and to identify when the decoder has failed to produce a correct codeword. When this code is used on a memoryless binary symmetric channel, the probability of codeword error is 10^{-5} when the channel bit error probablility is 0.5%, and the probability of undetected decoder error is upper bounded by 2.8×10^{-6} for all channel bit error probabilities. Synchronization acquisition, employing a 255-bit reference sequency, is far more tolerant to bit errors than the waveform itself. The probability of false synchronization in a random noise environment is less that 10^{-6} when the correlator threshold is set at 90. With this threshold the probability of missed synchronization is less than 10^{-6} for a 20% channel bit error probability. Sychronization performance is acceptable for truncated received sequences up to truncation levels of 50%.

Title: On Burst-Error Detecting Capability of Weighted Sum Codes
Author(s): Gam D. Nguyen
E-mail Address: nguyen@itd.nrl.navy.mil
Citation: Submitted to IEEE/ACM Transactions on Networking
Date: August 1995
Report No.: CS-95-014

Abstract

In this paper we give simple counterexamples showing that the guaranteed burst-error detecting capability of Weighted Sum Codes is only about half of that published in literature.

Title: A New Family of Reliable Error Detection Codes Having Low Complexity
Author(s): Gam D. Nguyen
E-mail Address: nguyen@itd.nrl.navy.mil
Citation: Submitted to IEEE Transactions on Information Theory
Date: December 1995
Report No.: CS-95-017

Abstract

Given an error-detection code, we define a new code called an inheritance code, which retains most of the error-detecting capabilities of the original code. Then, by combining the methods used to construct the weighted sum codes (WSCs) and the inheritance codes, we obtain a large family of new error-detecting codes that are reliable and of low complexity. The family, which we refer to as generalized weighted sum codes (GWSCs), contains WSCs as well as other optimal linear and nonlinear codes. The new GWSCs have efficient software and hardware implementations as well as flexible design parameters such as minimum distances, codeword lengths, and error-detecting capability. Trade-off between reliability and speed is a well-known limitation in software implementation of error-control coding. Therefore, the techniques of GWSCs make a new advance toward the solution of a long-standing problem of designing error-detection codes that are reliable and yet have low computational complexity.

Title: A Neural Network Approach to Solving the Link Activation Problem in Multihop Radio Networks
Author(s): C. M. Barnhart, J. E. Wieselthier, and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: IEEE Transactions on Communications, v43, pp1277-1283
Date: February/March/April 1995
Report No.: CS-95-018

Abstract

We address the problem of "link activation" or "scheduling" in multihop packet radio networks. The objective is to determine a conflict-free schedule of minimum length that satisfies the specified end-to-end communication requirements. It is well known that this problem, in almost all of its forms, is a combinatorial-optimization problem of high complexity. We approach this problem by the use of a Hopfield neural network model in which the method of Lagrange multipliers is used to vary dynamically the values of the coefficients used in the connection weights.

Title: Platform-Related Limitations to Efficiency in Standard Clock Simulation on Sequential Machines
Author(s): C. M. Barnhart, J. E. Wieselthier, and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Proceedings of the 1995 Summer Computer Simulation Conference, Ottawa, Ontario, Canada, pp15-20
Date: July 1995
Report No.: CS-95-019

Abstract

Standard Clock (SC) simulation is an efficient form of discrete-event simulation that is applicable to systems with exponential interevent times. It achieves its efficiency by using a common event stream to construct, on sequential or parallel machines, many sample paths in parallel. However, on sequential machines the efficiency is limited by two factors: (1) A fundamental simulation method-related limitation predicts an upper bound on achievable speedup that is determined by the ratio of the event generation time to the sample path update time. (2) There is also a platform-related limitation to efficiency that is a result of increasing memory requirements as the SC simulation is scaled. In this paper, we develop a slightly modified form of SC simulation that mitigates the loss of efficiency caused by memory management expenses. With this approach, groups of events, rather than individual events, are passed to each sample path so that the cache-break expense is amortized over the event group size.

Title: Noise Issues in Optical Linear Algebra Processor Design
Author(s): S. G. Batsell, J. F. Walkup, and T. F. Krile
E-mail Address: mcgregor@itd.nrl.navy.mil
Citation: Design Issues in Optical Processing, J. N. Lee, editor, Chapter , pp27-77, Cambridge University Press
Date: 1995
Report No.: CS-95-021

Abstract

Optical linear algebra processors (OLAPS) perform numerical calculations such as matrix-vector multiplication by equating a particular property of light, normally the light intensity level, to a number. Through various effects to be discussed in this section, uncertainty is introduced either through random fluctuations or the addition of a bias. The fluctuating intensity can now be considered a random variable for which a mean and standard deviation can be dtermined. After corrections for bias, the mean value can be taken as the correct level that relates to the expected numerical value while the non-zero standard deviation represents processor noise.

In the design of analog OLAPS such as matrix-vector and matrix-matrix processors, the effect of noise from both device and system sources has a major impact on the choice of system architecture and components. The ability of a

particular system design to meet system performance specifications such as signal-to-noise ratio (SNR), dynamic range, and accuracy is directly connected to the noise properties of the system and its components. As an example, the choice of the spatial light modulator (SLM) has a significant impact . This chapter examines the effects of noise on these system specifications and their implications for OLAP design.

We begin with a theoretical analysis of a simple matrix-vector multiplier and then generalize the results for N cascaded matrix-vector multipliers. From these analyses, the major noise sources will be identified and discussed. Their effect on the principle design criteria are then assessed. Finally, experimental results for systems employing several current SLMs are presented and discussed.

Title: The Implications of a Distributed Computing Paradigm on Multicast Routing
Author(s): S. G. Batsell and J. E. Klinker
E-mail Address: klinker@itd.nrl.navy.mil
Citation: Conference Record of IEEE MILCOM'95, San Diego, CA, pp241-245
Date: November 1995
Report No.: CS-95-022

Abstract

Significant interest exists within the military in moving towards an integrated service environment in which, in addition to traditional networking services such as ftp, telnet, e-mail, etc., various real-time services can co-exist on the same network. Real-time services of interest include voice, video, and satellite images. Moving a step further, an integrated service network can provide a distributed computing environment for such applications as distributed interactive simulation. To realize this environment, a number of advances are required, principally in intelligent use of the network environment including the reservation of resources, management of the traffic access to the network resources, and effective utilization of the network resources. Multicast routing is an important means of providing effective utilization of the network resources.

In developing multicast routing protocols, operational paradigms based on specific application classes are utilized. In the past, two paradigms have been used: the lecture model and the conference model. Both of these models make specific assumptions about the role of participants, how the groups are initiated, the system dynamics, and scalability of the protocol. This has lead to specific routing protocol solutions being biased toward lecture or conference applications at the expense of distributed computing applications such as distributed interactive simulation.

This paper defines the distributed computing paradigm for multicast routing and contrasts it with other multicast paradigms. This paradigm is then used to compare center-based trees and shortest-path trees on the basis of delay, cost, traffic concentration, scalability, protocol overhead, and state. Conclusions are then drawn from this analysis to determine which multicast routing protocol is best suited for distributed computing applications such as distributed interactive simulations.

Title: MCA Protocols and Algorithms
Author(s): K. Burrows, D. Nguyen, E. Rubin, E. Smythe, and W. Thoet
E-mail Address: mcgregor@itd.nrl.navy.mil
Citation: Internal Report
Date: November 1995
Report No.: CS-95-025

Abstract

This report describes a suite of algorithms that can be used to implement an integrated data/voice communication network operating over broadcast radio links. A new, distributed algorithm is given that allows for the rapid discovery and maintenance of backbone network in a mobile radio network. This backbone is used for a variety of services including: virtual circuit setup, network connectivity learning, user broadcasts, and conference voice applications. The network design supports both virtual-circuit and packet switching. Other algorithms covered in the report include: congestion control, routing, receiver scheduling, message multiplexing, and virtual circuit management.

Title: Performance Analysis of ATM Networks With Wireless Links
Author(s): J. B. Cain
E-mail Address: mcgregor@itd.nrl.navy.mil
Citation: Report, Harris Government Aerospace Systems Division, Melbourne, FL
Date: May 1995
Report No.: CS-95-026

Abstract

The purpose of this report is to provide interim results from a study to investigate the important issues involved in using Asynchronous Transfer Mode (ATM) over wireless data links (both SATCOM and terrestrial). These results will show that ATM, the basic transport mechanism for BISDN, can be made to perform satisfactorily over wireless data links if steps are taken to insure that certain RF link characteristics do not impair ATM operation. Some of the important ATM mechanisms were designed with the assumption that transmission bit errors are rare and randomly distributed. Using fiber-optic-based transmission systems, bit errors are extremely rare and cell losses occur primarily due to contention for congested switch and link resources. With wireless links the BER will be much higher and the bit errors may not be randomly distributed. The impact of these link characteristics on a variety of ATM functions and on overall system performance are presented in this report. We do not claim to have exhausted the analysis of architectural variations and control mechanisms possible with ATM networks using wireless data links. Some remaining open issues are discussed under the topic "Recommendations for Future Work."

Title: Key Performance Issues for ATM Networks with Wireless Links
Author(s): J. B. Cain and D. N. McGregor
E-mail Address: mcgregor@itd.nrl.navy.mil
Citation: Submitted to IEEE Journal on Selected Areas on Communications
Date: December 1995
Report No.: CS-95-027

Abstract

This paper provides analytical results of an analysis of some of the problems of using wireless links to transport ATM cells. We focus primarily on problems associated with point-to-point links rather than those associated with multiaccess links. Problems considered include the FEC and interleaving at the physical layer, the impact of wireless links on the ATM cell HEC and CD functions, some AAL layer issues, and the impact of the choice of end-to-end ARQ protocol for reliable service.

Title: Parallel Sample Path Generation for Discrete Event Systems and the Traffic Smoothing Problem
Author(s): C. G. Cassandras and J. Pan
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Journal of Discrete Event Dynamic Systems, v5, n2/3, pp187-218
Date: April/July 1995
Report No.: CS-95-028

Abstract

We review two approaches, the Standard Clock (SC) technique and Augmented System Analysis (ASA), that have been proposed for generating sample paths of Discrete Event Systems (DES) in parallel. These are placed in the unifying framework of the fundamental *sample path constructability* problem: for a finite discrete parameter set $\Theta = \{\theta_1,...,\theta_m\}$, given a sample path under θ_1, the problem is to simultaneously construct sample paths under all remaining parameter values. Using the ASA approach we then consider the problem of smoothing arbitrary, generally bursty, and possibly nonstationary traffic processes which are encountered in many applications, especially in the area of flow control for integrated-service, high-speed networks. We derive some basic structural properties of a smoothing scheme known as the Leaky Bucket (LB) mechanism through which it is seen that the variability of a traffic process can be monotonically decreased by decreasing an integer-valued parameter of this scheme. Finally, we show that a sample path under any value of this parameter is constructable with respect to an observed sample path under any other value. Therefore, by controlling this parameter on line, we show how simple iterative optimization schemes can be used to achieve typical design objectives such as keeping both the mean packet delay due to smoothing and the variability of the traffic process low.

Title: Scheduling Policies Using Marked/Phantom Slot Algorithms
Author(s): C. G. Cassandras and V. Julka
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Queueing Systems: Theory and Applications (QUESTA), v20, pp207-254
Date: 1995
Report No.: CS-95-029

Abstract

We address the problem of scheduling M customer classes in a single-server system, with customers arriving in one of N arrival streams, as it arises in scheduling transmissions in packet radio networks. In general, $N \neq M$ and a customer from some stream may join one of several classes. We consider a slotted time model where at each scheduling epoch the server (channel) is assigned to a particular class (transmission set) and can serve multiple customers (packets) simultaneously, one from every arrival stream (network node) that can belong to this class. The assignment is based on a *random polling* policy: the current time slot is allocated to the ith class with probability θ_i. Our objective is to determine the optimal probabilities by adjusting them online so as to optimize some overall performance measure. We present an approach based on perturbation analysis techniques, where all customer arrival processes can be arbitrary, and no information about them is required. The basis of this approach is the development of two sensitivity estimators leading to a *Marked Slot* and a *Phantom Slot* algorithm. The algorithms determine the effect of removing/adding service slots to an existing schedule on the mean customer waiting times by directly observing the system. The optimal slot assignment probabilities are then used to design a *deterministic* scheduling policy based on the Golden Ratio policy. Finally, several numerical results based on a simple optimization algorithm are included.

Title: A Reservation Based Multicast (RBM) Routing Protocol for Mobile Networks: Initial Route Construction Phase
Author(s): M. S. Corson and S. G. Batsell
E-mail Address: mcgregor@itd.nrl.navy.mil
Citation: Invited paper in the ACM Journal of Wireless Networks, v1-4, pp427-450
Date: December 1995
Report No.: CS-95-030

Abstract

We propose a combined multicast routing, resource reservation and admission control protocol, termed Reservation-Based Multicast (RBM), that borrows the "Rendezvous Point" or "Core" concept from multicast routing algorithms proposed for the Internet, but which is intended for operation in mobile networks and routes hierarchically-encoded data streams based on user-specified fidelity requirements, real-time delivery thresholds and prevailing network bandwidth constraints. The protocol exhibits the fully distributed

operation and receiver-initiated orientation of these proposed algorithms; but, unlike them, the protocol is tightly coupled to a class of underlying, distributed, unicast routing protocols thereby facilitating operation in a dynamic topology. This paper focuses on the initial route construction phase, assumed to occur during a static "snapshot" of the dynamic topology, and is therefore applicable to fixed networks as well, e.g. the Internet.

Title: A Reservation Based Multicast (RBM) Routing Protocol for Mobile Networks: Initial Routing Construction
Author(s): M. S. Corson and S. G. Batsell
E-mail Address: mcgregor@itd.nrl.navy.mil
Citation: Proceedings of IEEE INFOCOM '95, Boston, MA, pp1063-1074
Date: April 1995
Report No.: CS-95-031

Abstract

We propose a combined multicast routing and resource reservation protocol, termed Reservation-Based Multicast (RBM), that performs routing in a fashion similar to Protocol Independent Multicast (PIM), but which is intended for mobile operation and routes hierarchically-encoded data streams based on user-specified fidelity requirements, real-time delivery thresholds and prevailing network bandwidth constraints. The protocol retains the fully distributed operation, scalability and receiver-initiated orientation of PIM; but, unlike PIM, the protocol is tightly coupled to an underlying, distributed, unicast routing protocol thereby facilitating operation in a dynamic topology. This paper focuses on the initial route construction phase, assumed to occur during a static "snapshot" of the dynamic topology, and therefore outlines an approach to reservation-based multicast routing for fixed networks as well, e.g. the Internet.

Title: Admission Control and Bandwidth Allocation in High-Speed Networks as a System Theory Control Problem
Author(s): A. Ephremides, J. E. Wieselthier, and C. M. Barnhart
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Proceedings of the 34th IEEE Conference on Decision and Control, New Orleans, LA, pp359-365
Date: December 1995
Report No.: CS-95-032

Abstract

In this paper we offer a somewhat qualitative and descriptive review of a modeling approach for the problems of admission control and bandwidth allocation in communication networks with emphasis on broadband (or high-speed) applications and issues such as multicasting and ATM. We extend previous models that permit appropriate optimization formulations and apply previously successful tools for their solution.

Title: A Multiple-Access Scheme for Voice/Data Integration in Hybrid
  Satellite/Terrestrial Packet Radio Networks
Author(s): E. Geraniotis, M. Soroushnejad, and W.-B. Yang
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: IEEE Transactions on Communications, v43, n2/3/4, pp1756-1767
Date: February/March/April 1995
Report No.: CS-95-033

Abstract

This paper examines protocols for voice/data integration in hybrid packet
radio networks consisting of satellite and terrestrial components. The same
protocols can be useful in the context of mixed-media packet radio networks
employing HF ground radio links and EHF SATCOM radio links. As part of our
integration protocol the ground subnetwork employs code-division multiple-
access with movable boundary in the code domain to serve both the voice traffic
and the retransmitted data traffic; on the satellite subnetwork framed ALOHA with
movable boundary is used for both data and voice.

A complete analysis of the channel-access protocols for both traffic types is
provided based on a multi-dimensional Markovian model of the integrated
voice/data system. The performance of the hybrid network is evaluated in terms
of voice and data throughput, voice blocking probability, and data delay. It is
observed that appropriate splitting of the retransmission traffic between the
satellite and ground subnets may increase the overall data throughput when the
voice load is high.

Title: Adding SNMP Interface to Applications
Author(s): R. R. Nair
E-mail Address: nair@itd.nrl.navy.mil
Citation: Presented at the TCP/IP EXPO, San Jose, CA
Date: August 1995
Report No.: CS-95-034

Abstract

Defense Simulation Internet (DSI) is the infrastructure for large scale
Distributed Interactive Simulation (DIS) exercises. DSI consists of high speed
WANs interconnecting multiple LAN sites. Gateway software is needed between
WAN and LAN segments to monitor/control traffic between the segments. The
presentation describes the application of SNMP to manage this gateway
software.

Title: Design of SNMP Interface for Application Control Software
Author(s): R. R. Nair
E-mail Address: nair@itd.nrl.navy.mil
Citation: Internal Report
Date: April 1995
Report No.: CS-95-035

Abstract

The purpose of this document is to explain the SNMP interface for AH, AT and HPAG components. The SNMP interface is comprised of the following components: an SNMP Master Agent which support SNMPv1 concurrently with multiple sub-agent and proxy mechanisms, multiple (one for each application process to be managed) Management Information Bases (MIBs) incorporating all the variables to be monitored/managed using SNMP, and the same number of sub-agents which link with the managed applications. This makes the applications manageable using SNMP.

Title: Multi-Access Strategies for an Integrated Voice/Data CDMA Packet Radio Network

Author(s): M. Soroushnejad and E. Geraniotis
E-mail Address: wieselthier@itd.nrl.navy.mil

Abstract

Multiple-access schemes are introduced and analyzed for the integration of voice and data traffic in packet radio networks using code-division multiple-access (CDMA). The multiple-access capability of the CDMA channel is used to accommodate several voice calls simultaneously, while the data users follow the ALOHA protocol with retransmission control and content for the remaining (if any) multiple-access capability of that channel. The retransmission probabilities implemented by the backlogged data users are updated based on estimates of data backlog and number of established voice calls; these estimates are obtained from the side information (feedback) about the state of channel activities. Retransmission schemes based on different feedback information are investigated.

A two-dimensional Markovian model is developed for the voice and data traffic, with the data backlog and number of established voice calls representing the state of the system. Based on this model, the voice-call blocking probability, the throughput of both traffic types, and the delay of the data packets are evaluated and the tradeoffs between the parameters of different traffic types are quantified. The voice/data integration schemes introduced achieve efficient movable-boundary channel access in the code (CDMA) domain.

Title: A Mini-Product-Form-Based Solution to Data-Delay Evaluation in Wireless Integrated Voice/Data Networks

Author(s): J. E. Wieselthier, C. M. Barnhart, and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil

Abstract

Although the product-form solution provides an accurate characterization of equilibrium voice-traffic behavior in wireless integrated voice/data networks, it does not directly provide a method to evaluate data-packet delay. However, examination of each link separately in a manner that incorporates interaction with the rest of the network permits us to take advantage of the wireless nature of the network and obtain a three-flow characterization of each link, which also satisfies a product-form solution and is hence termed a "mini-product-form" solution. By matching the values of these flows, which are natural to the wireless network, to the average values obtained from the product-form solution of the entire network, we obtain a three-dimensional Markov chain characterization of the voice occupancy state on the link, which permits a simpler evaluation of data-packet delay. A further reduction is possible by converting the three-dimensional chain to a single-dimensional one.

Title: Fixed- and Movable-Boundary Channel-Access Schemes for Integrated Voice/Data Networks
Author(s): J. E. Wieselthier and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: IEEE Transactions on Communications, v43, pp64-74
Date: January 1995
Report No.: CS-95-038

Abstract

In this paper we address the major issues associated with channel access in integrated wireless networks, and we propose and analyze the "Wireless Integrated Multiple Access" (WIMA) protocol. This scheme is based on a mixture of boundary ideas for integration of previously introduced protocols for wireless access, and is well suited to either satellite or to terrestrial networks. A two-dimensional first-order Markov chain model for this scheme is presented, and techniques that exploit the structural properties of this chain to simplify the evaluation of the equilibrium state, without sacrificing accuracy, are described. Analytical models for the evaluation of data-packet delay for both fixed- and movable-boundary versions of this protocol and for voice-call blocking probability are presented. Performance results illustrate the dependence of performance on system parameters, and demonstrate the improved performance that can be achieved through the use of the movable-boundary version.

Title: Data-Delay Evaluation in Integrated Wireless Networks based on Local Product-Form Solutions for Voice Occupancy
Author(s): J. E. Wieselthier, C. M. Barnhart, and A. Ephremides
E-mail Address: wieselthier@itd.nrl.navy.mil
Citation: Invited paper to appear in the ACM Journal of Wireless Networks
Date: November 1995
Report No.: CS-95-039

Abstract

In this paper we consider the evaluation of data-packet delay in wireless integrated voice/data networks. In networks that support voice in the classical circuit-switched fashion, the voice occupancy process satisfies a product-form solution under reasonable modeling assumptions. Although this product-form solution provides an accurate characterization of equilibrium voice-traffic behavior, it does not directly provide a method to evaluate data-packet delay. However, examination of each link separately in a manner that incorporates interaction with the rest of the network permits us to take advantage of the wireless nature of the network and obtain a three-flow characterization of each link, which also satisfies a product-form solution and is hence termed a "mini-product-form" solution. By matching the values of these flows, which are natural to the wireless network, to the average values obtained from the product-form solution of the entire network, we obtain a three-dimensional Markov chain characterization of the voice occupancy state on the link, which permits a simpler evaluation of data-packet delay. A further reduction is possible by converting the three-dimensional chain to a single-dimensional one. Performance results demonstrate that these models provide satisfactory delay estimates that also appear to be upper bounds on delay.

Abstract

The Naval Research Laboratory (NRL) has developed technology to support integrated multimedia services in military tactical communication systems. Because of the limited data rate available in tactical radio-frequency transmission systems, support of multiple services within a single communication system is presently almost nonexistent. This paper describes technology that NRL has developed to support selectable-rate networked voice, e-mail, interactive applications, and file and image transfer over a high-frequency (3 - 30 MHz) wireless network that is intended to operate among Navy ships using the surface-wave mode of propagation. The same technology will support UHF (225 - 400 MHz) line-of-sight wireless networks.

Abstract

This report summarizes our current understanding of requirements for a SINCGARS networking system for littoral and expeditionary warfare combat operations based on elevated relay platforms, hereinafter called the system. These understandings are based on requirements oriented interviews with personnel from U. S. Marine Corps Combat Development Command (MCCDC) - Quantico and U.S. Navy Space and Warfare Systems Command (SPAWAR). Throughout the report that follows, each subject is explored in a discussion paragraph to describe the rationale for the requirement. Following each subject discussion is a paragraph providing a concise statement of a requirement.

Abstract

Data communication systems have taken an important role in today's theater of warfare where rapid dissemination of information in the form of command and control, intelligence, or targeting data can be a deciding factor in warfighting scenarios. More recently, multi-national cooperation in crisis situations has become more common. As a result, interoperable communication systems to facilitate this cooperation have become essential. NRL is participating in the NATO Communication System Network Interoperability (CSNI) project which will demonstrate a multi-national, interoperable radio communication network.

The premise of CSNI is to demonstrate typical military communication applications (messaging, tactical data, and digital voice) with typical tactical radio links (HF ionosphere, UHF SATCOM, and SHF SATCOM). The key to interoperability is the application of an inter-networked communication architecture to facilitate transfer of data among the different radio frequency (RF) media. This discussion will focus on the communication architecture to be demonstrated, NRL's role in the project, and the issues encountered in developing a demonstration system on a multi-national basis with seven different participating countries in terms of project management and technology exchange.

1994 PUBLICATIONS

CS-94-001 Ordinal Optimization by Means of Standard Clock Simulation and Crude Analytical Models, *Craig M. Barnhart, Jeffrey E. Wieselthier, and Anthony Ephremides*

CS-94-002 Reed-Solomon Coding Performance with Errors and Erasures Decoding on a Rayleigh Fading Channel, *Paul J. Crepeau and Karen W. Halford*

CS-94-003 Integrated Computer Aided Design Practices As Demonstrated On a Fin-Line Device, *J. A. Molnar*

CS-94-004 Ordinal Optimization of Admission Control in Wireless Multihop Integrated Networks via Standard Clock Simulation, *Jeffrey E. Wieselthier and Craig M. Barnhart*

CS-94-005 A New Look at Double Error Correcting BCH Codes, *P. J. Crepeau*

CS-94-006 Discrete-Event-Dynamic-System-Based Approaches for Control in Integrated Voice/Data Multihop Radio Networks, *J. E. Wieselthier, C. G. Cassandras, and Vibhor Julka*

CS-94-007 Book Review of "The Collected Papers of Claude Shannon", *P.J. Crepeau*

CS-94-008 Schemes for Reliable Message Delivery in NATO Improved Link Eleven (NILE) Networks, *M.J. Chung and D.G. Kallgren*

CS-94-009 A Mini-Product-Form-Based Solution to Data-Delay Evaluation in Wireless Integrated Voice/Data Networks, *J.E. Wieselthier, C.M. Barnhart and A. Ephremides*

CS-94-010 Functional, Electrical, and Mechanical Description of the W-Band Noise Measurement System and the NRL W-Band VXI Module, *J.A. Molnar and T.V. Mai*

CS-94-011 An Integrated Knowledge Acquisition and Database Management System, *C.B. Barclay and J.A. Molnar*

1993 PUBLICATIONS

CS-93-001 A High Fidelity Network Simulator for SDI, *E. L. Althouse, D. N. McGregor, R. R. Nair, and S. G. Batsell*

CS-93-002 An Approach to Voice Admission Control in Multihop Wireless Networks, *C. M. Barnhart, J. E. Wieselthier, and A. Ephremides*

CS-93-003 Improvement in Simulation Efficiency by Means of the Standard Clock: A Quantitative Study, *C. M. Barnhart, J. E. Wieselthier, and A. Ephremides*

CS-93-004 Use of the Standard Clock to Improve Simulation Efficiency: A Quantitative Study Based on the M/M/1/K Queue, *C. M. Barnhart, J. E. Wieselthier, and A. Ephremides*

CS-93-005 Admission Control In Integrated Voice/Data Multihop Radio Networks, *C.M. Barnhart, J. E. Wieselthier, and A. Ephremides*

CS-93-006 A Neural Network Approach to Solving the Link Activation Problem in Multihop Radio Networks, *C. M. Barnhart, J. E. Wieselthier, and A. Ephremides*

CS-93-007 DC HULLCOM, Improvements in Shipboard Acoustical Communications: Adaptive Equalization, *S. Batsell, D. Arango, T. Pham, and T. Street*

CS-93-008 HiFiNS: An Object-Oriented Simulation of Large-Scale Communication Networks, *S. G. Batsell, D. N. McGregor, R. R. Nair, and E. L. Althouse*

CS-93-009 Analysis of a Threshold Priority Queuing System with Applications to ATM, *A. Battou (Locus, Inc.) and G. Nguyen*

CS-93-010 Strategic Engagement Planning Using a High Fidelity Network Simulation, *J. Carder, S. Mallder, and S. Butler (Booz•Allen & Hamilton, Inc.)*

CS-93-011 Perturbation Analysis and 'Rapid Learning' in the Control of Manufacturing Systems, *C. G. Cassandras (University of Massachusetts, Amherst)*

CS-93-012 'Rapid Learning' Techniques for Discrete Event Systems: Some Recent Results and Applications to Traffic Smoothing, *C. G. Cassandras (University of Massachusetts, Amherst)*

CS-93-013 Optimal Scheduling in Systems with Delay-Sensitive Traffic *C. G. Cassandras and V. Julka (University of Massachusetts, Amherst)*

CS-93-014 A New Approach for Some Combinatorially Hard Stochastic Optimization Problems, *C. G. Cassandras and V. Julka (University of Massachusetts, Amherst)*

CS-93-015 Marked/Phantom Slot Algorithms for a Class of Scheduling Problems, *C. G. Cassandras and V. Julka (University of Massachusetts)*

CS-93-016 Control of Integrated Voice/Data Multi-Hop Radio Networks Via Reduced-Load Approximations, *E. Geraniotis and I.-H. Lin (Locus, Inc. and University of Maryland)*

CS-93-017 Admission Control for Integrated Voice/Data Multi-Hop Radio Networks Via Reduced-Load Approximations, *E. Geraniotis and I.-H. Lin (Locus, Inc. and University of Maryland)*

CS-93-018 Parallel Computation in the Design and Stochastic Optimization of Discrete Event Systems, *Y. C. Ho (Harvard) and C. G. Cassandras (University of Massachusetts*

CS-93-019 High-Fidelity Protocol Modeling Issues in Large-Scale Network Simulations, *M. R. McDonald, J. B. Cain, J. W. Nieto, and K. Edwards (Harris Corp.)*

CS-93-020 Simulation of Large-Scale Strategic Communication Networks, *D. N. McGregor, R. R. Nair, S. G. Batsell, E. L. Althouse*

CS-93-021 Efficient Algorithms for Performing Packet Broadcasts in a Mesh Network, *E. Modiano and A. Ephremides*

CS-93-022 An Approach for the Analysis of Packet Delay in an Integrated Mobile Radio Network, *E. Modiano, J. E. Wieselthier, and A. Ephremides*

CS-93-023 A Model for the Approximation of Interacting Queues that Arise in Multiple Access Schemes, *E. Modiano and A. Ephremides*

CS-93-024 A Method for Delay Analysis of Interacting Queues in Multiple Access Systems, *E. Modiano and A. Ephremides*

CS-93-025 A Simple Analysis of Queuing Delay in a Tree Network of Discrete-Time Queues with Constant Service Tim, *E. Modiano, J. E. Wieselthier, and A. Ephremides*

CS-93-026 Reliability Analysis for FDDI Dual Homing Networks (Proceedings), *G. D. Nguyen*

CS-93-027 Reliability Analysis for FDDI Dual Homing Networks (NRL Report), *G. D. Nguyen*

CS-93-028 DC HULLCOM, Improvements in Shipboard Acoustical Communications: Channel Modeling and Modulation Techniques, *T. T. Street, S. G. Batsell, D. A. Arango, T. V. Pham, T. J. Aberle, J.*

CS-93-029 A Multi-Channel Architecture for Naval Task Force Communication, *W. A. Thoet (Booz•Allen & Hamilton, Inc.), D. J. Baker, and D. N. McGregor*

CS-93-030 Efficient Simulation of DEDS by Means of Standard Clock Techniques: Queuing and Integrated Radio Network Examples, *J. E. Wieselthier, C. M. Barnhart, and A. Ephremides*

CS-93-031 Performance Analysis of Fixed- and Movable-Boundary Channel-Access Schemes for Integrated Voice/Data Wireless Networks, *J. E. Wieselthier and A. Ephremides*

CS-93-032 Ordinal Optimization of Admission Control in Wireless Multihop Voice/Data Networks Via Standard Clock Simulation, *J. E. Wieselthier, C. M. Barnhart, and A. Ephremides*

CS-93-033 A Neural Network Approach To Routing Without Interference In Multihop Radio Networks, *J. E. Wieselthier, C. M. Barnhart, and A. Ephremides*

CS-93-034 Fixed- And Movable-Boundary Channel-Access Schemes For Integrated Voice/Data Wireless Networks, *J. E. Wieselthier and A. Ephremides*

CS-93-035 On the Problems of Data-Delay Evaluation and Minimization in Integrated Voice/Data Networks, *J. E. Wieselthier, C. M. Barnhart, and A. Ephremides*

CS-93-036 A Channel Simulation Processor for the Multi-Node Tactical Network Simulator, *Joseph P. Macker*

CS-93-037 Admission-Control Policies for Integrated Communication Networks, *C. M. Barnhart, J. E. Wieselthier, and A. Ephremides*

CS-93-038 Modeling, Performance Evaluation, and Ordinal Optimization of Integrated Voice/Data Networks, *J. E. Wieselthier, C. M. Barnhart, and A. Ephremides*

CS-93-039 SG-1157/U Digital Processing Clock Operations and Maintenance Manual, *T. H. Gattis, J. J. O'Neill, and J. A. Bowman*

CS-93-040 Expert System Enhancements to Fault Isolation System Knowledge Acquisition, *J.A. Molnar, C. Barclay*

CS-93-041 Functional, Electrical, and Mechanical Description of the W-Band Noise Measurement System and the NRL W-Band VXI Module, *J. A. Molnar and T. V. Mai*

CS-93-042 VXI Implementation of a Millimeter Wave Measurement System, *J. A. Molnar and T. V. Mai*

CS-93-043 Multidimensional Electromagnetic Simulation of Microwave and Millimeter-Wave Structures, *J. A. Molnar and C. M. Crown*

CS-93-044 VXI Millimeter-Wave Signal Generator Architecture, *J. A. Molnar*

CS-93-045 Integration of TAE Plus with Empress Database Management Software, *C. Barclay and J. A. Molnar*

IV. CENTER FOR HIGH ASSURANCE COMPUTER SYSTEMS

CODE 5540

The Center for High Assurance Computer Systems (CHACS) performs research and develops technology in areas supporting military requirements for communication security (COMSEC) and computer security (COMPUSEC). Emphasis is given to the development of concepts, architectures, analysis techniques and methodology that exploit appropriately the opportunities available through systematic consideration of the total security problem and its impact on communication and computer systems. The Center provides leadership and is the Navy's lead laboratory for research and development of COMPUSEC technology and evaluation techniques. Areas of activity include development of information security devices, subsystems and system technology through the conceptual, analysis and experimentation, and proof-of-concept phases. The Center works closely with Navy system developers and with the National Security Agency.

Title: Epistemology of Information Flow in the Multilevel Security of Probabilistic
   Systems

Author(s): Paul F. Syverson and James W. Gray, III
E-mail Address: syverson@itd.nrl.navy.mil

Abstract:

We set out a modal logic for reasoning about multilevel security of
probabilistic systems. This logic includes modalities for time, probability,
knowledge, and permitted-knowledge. Making use of the Halpern-Tuttle
framework for reasoning about knowledge and probability, we give a semantics
for our logic and prove that it is sound. We give two syntactic definitions of
perfect multilevel security and show that their semantic interpretations are
equivalent to two earlier, independently motivated characterizations. We also
discuss the relation between these characterizations of security and between
their usefulness in security analysis.

Title: Software Requirements: A Tutorial

Author(s): Stuart R. Faulk

Abstract:

Deciding precisely what to build and documenting the results is the goal of the
requirements phase of software development. Experience shows that
requirements are the biggest software engineering problem for developers of
large, complex systems. The purpose of this tutorial is to help the reader
understand why requirements are so difficult to do well, where the state of the art
does and does not address current development problems, the strengths and
weaknesses of different approaches to requirements, and what help we can
expect from ongoing technical developments.

Focus of the tutorial is on providing the reader with an understanding of the
underlying issues in requirements analysis and specification. It describes the
different facets of the requirements problem from the points of view of the many
parties involved in system development, including customers, contractors,
management, regulators, and developers. It discusses the goals of the
requirements phase and the problems that can arise in achieving those goals. It
describes the characteristics of a disciplined software engineering process and
how such a process helps address many of the problems in requirements. It
compares a variety of published approaches relative to the goals of a disciplined
process. Finally it examines technical trends, including recent work at the Naval
Research Laboratory, and discusses where the significant advances are likely in
the future.

Title: Security for the Internet Protocol
Author(s): Randall J. Atkinson
Citation: Naval Research Laboratory Formal Report, NRL/FR/5540--95-9795
Date: November 30, 1995
Report No.: CHACS-95-003

Abstract:

Lack of widely available security is hindering the growth of the Internet, particularly for commercial users. Two security mechanisms have been designed for use with IPv4 and IPv6. They are an integral component of the IPv6 design but can also optionally work with IPv4. The first mechanism provides source host authentication and information integrity protection without confidentiality and should be exportable and widely deployable. The second mechanism protects the confidentiality of packet contents through the use of encryption. Both mechanisms are designed to be independent of any particular cryptographic algorithm so that new algorithms can be supported in the future without any change to the basic protocols.

Title: External COMSEC Adaptor Software Engineering Methodology
Author(s): Andrew Moore, Eather Chapman, et al.
E-mail Address: moore@itd.nrl.navy.mil or chapman@itd.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5542--95-7768
Date: August 31, 1995
Report No.: CHACS-95-004

Abstract:

The External COMSEC Adaptor (ECA) is a device responsible for providing cryptographic protection of information based rules that (possibly) coarsely define the sensitivity of that information. The ECA is trusted to satisfy a set of critical requirements that support a requirement of data confidentiality in the network in which it is embedded. Ensuring that the ECA is worthy of this trust requires precisely defining its critical requirements and constructing a strong argument that its implementation satisfies these requirements. This paper describes a software engineering methodology that uses formal methods for specifying and verifying the most critical requirements of the ECA and uses testing and simulation for verifying the overall functional requirements of the ECA. The methodology integrates the formal specifications and proofs with structured software documentation to clarify the relationship between the refinement of ECA functionality and the argument that the ECA meets its critical requirements. This methodology was used successfully to build the ECA using the KG84A to satisfy its cryptographic requirement.

Title: A Data Pump for Communication
Author(s): Myong H. Kang and Ira S. Moskowitz
E-mail Address: mkang@itd.nrl.navy.mil or moskowitz@itd.nrl.navy.mil
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5540--95-7771
Date: September 29, 1995
Report No.: CHACS-95-005

Abstract:

As computer systems become more open and interconnected, the need for reliable and secure communication also increases. In this paper, we introduce a communication device, the Pump, that balances the requirements of reliability and security. The Pump provides acknowledgments (ACKs) to the message source to insure reliability. These ACKs are also used to regulate the source to prevent the Pump's buffer from becoming/staying full. This is desirable because once the buffer is filled there exists a huge covert communication channel. The Pump controls the input rate from the source by attempting to slave the input rate to the service rate through the randomized ACK back to the source.

An analysis of the covert channel is also presented. The purpose of the covert channel analysis is to provide guidelines for the designer of the Pump to choose appropriate design parameters (e.g., size of buffer) dependent upon the analysis presented in this paper system requirements.

Title: Improving Inter-Enclave Information Flow for a Secure Strike Planning Application
Author(s): Judith N. Froscher., et.al.
E-mail Address: froscher@itd.nrl.navy.mil
Citation: Proceedings of the 11th Annual Computer Security Applications Conference, New Orleans, pp89-98
Date: December, 1995
Report No.: CHACS-95-006

Abstract:

DoD operates many system high enclaves with limited information flow between enclaves at different security levels. Too often, the result is duplication of operations and inconsistent and untimely data at different sites, which reduces the effectiveness of DoD decision support systems. This paper describes our solution to this problem as it arises in installations of the Joint Maritime Command Information System (JMCIS), an integrated C4I system. Our approach views databases in more classified enclaves as potential replica sites for data from less classified enclaves. Replicated data flows from lower enclaves to higher ones via one-way connections, yielding a high assurance MLS (multi-level secure) distributed system. The one-way connections are the only trusted components. This approach is based on our work on SINTRA (Secure Information Through Replicated Architecture), and applies generally to any collection of systems each running a database at system high. It complements and exploits modern system design methods, which separate data management

from data processing, and enables effective, low-cost MLS operation within that paradigm. In addition to describing current JMCIS installations and our architectural approach, the paper presents our approach for justifying a system's security and our use of formal methods to increase assurance that security requirements are met.

Title: SCR*: A Toolset for Specifying and Analyzing Requirements
Author(s): C. Heitmeyer, A. Bull, C. Gasarch and B. Labaw
E-mail Address: heitmeyer@itd.nrl.navy.mil or gasarch@itd.nrl.navy.mil or labaw@itd.nrl.navy.mil
Citation: Proceedings of the Tenth Annual Conference on Computer Assurance (COMPASS '95), Gaithersburg, MD, pp109-122
Date: June 25-29, 1995
Report No.: CHACS-95-007

Abstract:

A set of CASE tools is described for developing formal requirements specifications expressed in the SCR (Software Cost Reduction) tabular notation. The tools include an editor for building the specifications, a consistency checker for testing the specifications for consistency with a formal requirements model, a simulator for symbolically executing the specifications, and a verifier for checking that the specifications satisfy selected application properties. As background, the SCR method for specifying requirements is reviewed, and a formal requirements model is introduced. Examples are presented to illustrate the tools.

Title: A Network Pump
Author(s): Myong H. Kang, Ira S. Moskowitz, and Daniel C. Lee
E-mail Address: mkang@itd.nrl.navy.mil or moskowitz@itd.nrl.navy.mil or lee@kingcrab.nrl.navy.mil
Citation: Preprint
Date: 1995
Report No.: CHACS-95-008

Abstract:

As computer systems become more open and interconnected, the need for reliable and secure communication also increases. In this paper, we introduce a communication device, the Pump, that balances the requirements of reliability and security. The Pump provides acknowledgements (ACKs) to the message source to insure reliability. These ACKs are also used to regulate the source to prevent the Pump's buffer from becoming/staying full. This is desirable because once the buffer is filled exists a huge covert communication channel. The Pump controls the input rate from the source by attempting to slave the input rate to the service rate through the randomized ACK back to the source. An analysis of the covert channel is also presented. The purpose of the covert channel analysis is to provide guidelines for the designer of the Pump to choose appropriate design parameters (e.g., size of buffer) dependent upon the analysis presented in this paper and system requirements.

Title: Storage Jamming
Author(s): John McDermott and David Goldschlag
E-mail Address: goldschlag@itd.nrl.navy.mil
Citation: Database Security IX: Status and Prospects, pp365-381
Date: 1995
Report No.: CHACS-95-009

Abstract:

In the past, the most likely motive for attacks that modify data would have been financial gain. However, changes in technology have made many organizations so dependent on information systems that it is now possible to disrupt or degrade their operations by interfering with their supporting information systems. When this disruption is accomplished by unauthorized modification of data, we call it "Storage Jamming". Storage jamming is the malicious modification of stored data, done for the purpose of degrading or disrupting real-world operations that depend on the correctness of the data. We assume the person initiating the malicious modification (frequently via a Trojan horse) does not receive any direct benefit, financial or otherwise, but rather is motivated by more indirect goals such as improving the competitive position of his or her own organization. The main goal of this paper is to define storage jamming. We also discuss our work to date on possible defenses against it in order to make the case that there are solutions. We first discuss the nature of storage jamming including possible jamming strategies and vulnerability to jamming. The next two sections discuss a variety of anti-jamming techniques. Some of these candidate techniques are based on previous work on security-oriented data integrity but are unsuitable for use against jamming attacks. We then discuss a particular kind of anti-jamming mechanism called a detection object. The paper ends with a summary and discussion of future work.

Title: One-Time Passwords In Everything (OPIE): Experiences with Building and Using Strong Authentication
Author(s): Daniel L. McDonald, R.J. Atkinson, and Craig Metz
E-mail Address: danmcd@itd.nrl.navy.mil or atkinson@itd.nrl.navy.mil
Citation: Proceedings of the 5th USENIX UNIX Security Symposium, Salt Lake City, UT, pp177-186
Date: June 5-7, 1995
Report No.: CHACS-95-010

Abstract:

The U.S. Naval Research Laboratory's OPIE (One-time Passwords in Everything) Software Distribution is an enhancement of Bellcore's S/Key ™ 1.0 package. OPIE improves on S/Key in several areas, including FTP service with one-time passwords, and a stronger algorithm for generating one-time passwords. OPIE diverges from S/Key in select design decisions and in the behavior of certain programs. While not a total security solution, OPIE can be an important part of one. OPIE and its evolutionary predecessors have been used for over a year in parts of NRL. Its use has taught the authors lessons on implementation, usability, deployment, and future directions for improvement.

Title: High Assurance Computer Systems: A Research Agenda, America in the
Age of Information
Author(s): John D. McLean and C.L. Heitmeyer
E-mail Address: mclean@itd.nrl.navy.mil or heitmeyer@itd.nrl.navy.mil
Citation: National Science and Technology Council Committee on Information
and Communications Forum, Bethesda, MD
Date: 1995.
Report No.: CHACS-95-011

Abstract:

Many scientific approaches for specifying, constructing, and certifying high
assurance systems have been developed, including formal verification and
validation techniques. Much still needs to be done with respect to individual
critical properties (e.g., safety, security, and timeliness). Even more needs to be
done with respect to (1) the lack of technology support for applying these
techniques to practical, real-world systems, and (2) the lack of a unified
framework for building systems that satisfy several critical properties. These
problems are of such a difficult nature that they will not be solved by industry or
academia without the support of both government funding agencies and
government research laboratories. This paper summarizes the results of a
workshop in which a group of 50 experts from academia, government, and
industry participated to address these challenges.

Title: Applying the Dependability Paradigm to Computer Security
Author(s): Catherine A. Meadows
E-mail Address: meadows@itd.nrl.navy.mil
Citation: Proceedings of the 1995 New Security Paradigms Workshop, pp75-79
Date: August 22-25, 1995
Report No.: CHACS-95-012

Abstract:

Dependability is that property of a computer system such that reliance can
justifiably be placed on the service it delivers. In this paper, we contrast the
different ways faults are handled in the dependability paradigm with the way they
are handled in the current paradigms for secure system design. We show how
the current security paradigm is generally restricted to a subset of the types of
approaches used in dependability, largely concentrating on fault prevention and
removal while neglecting fault tolerance and forecast, and argue that this
paradigm is fast becoming obsolete. We discuss the implications of extending the
security paradigm to cover the full range of options covered by dependability. In
particular, we develop a rough outline of a fault model for security and show how
it could be applied to better our understanding of the place of both fault tolerance
and fault forecast in computer security.

Title: Using Temporal Logic to Specify and Verify Cryptographic Protocols
(Progress Report)
Author(s): James W. Gray, III and John D. McLean
E-mail Address: mclean@itd.nrl.navy.mil
Citation: Proceedings of the 8th IEEE Computer Security Foundations
Workshop, IEEE Press, pp108-116
Date: June 13-15, 1995
Report No.: CHACS-95-013

Abstract:

We use standard linear-time temporal logic to specify cryptographic protocols, model the system penetrator, and specify correctness requirements. The requirements are specified as standard safety properties, for which standard proof techniques apply. In particular, we are able to prove that the system penetrator cannot obtain a session key by any logical or algebraic techniques. We compare our work to Meadows' method. We argue that using standard temporal logic provides greater flexibility and generality, firmer foundations, easier integration with other formal methods, and greater confidence in the verification results.

Title: The NRL Protocol Analyzer: An Overview
Author(s): Catherine A. Meadows
E-mail Address: meadows@itd.nrl.navy.mil
Citation: Journal of Logic Programming, v26, n2, pp113-132
Date: February, 1995
Report No.: CHACS-95-014

Abstract:

The NRL Protocol Analyzer is a prototype special-purpose verification tool, written in Prolog, that has been developed for the analysis of cryptographic protocols that are used to authenticate principals and services and distribute keys in a network. In this paper we give an overview of how the Analyzer works and describe its achievements so far. We also show how our use of Prolog benefited us in the design and implementation of the Analyzer. This is a greatly expanded version of the paper "The NRL Protocol Analyzer: An Overview, " that appeared in the proceedings of the 2nd Conference on the Practical Applications of Logic Programming.

Title: Formal Verification of Cryptographic Protocols: A Survey
Author(s): Catherine Meadows
E-mail Address: meadows@itd.nrl.navy.mil
Citation: Advances in Cryptology - Asiacrypt '94, LNSC 917, Springer-Verlag,
pp133-150
Date: 1995
Report No.: CHACS-95-015

Abstract:

In this paper we give a survey of the state of the art in the application of formal methods to the analysis of cryptographic protocols. We attempt to outline some of the major threads of research in this area, and also to document some emerging trends.

Title: Integrity in Multilevel Secure Database Management Systems
Author(s): Catherine Meadows and Sushil Jajodia
E-mail Address: meadows@itd.nrl.navy.mil
Citation: Information Security: An Integrated Collection of Essays (ed. M. Abrams, S. Jajodia, and M. Podell), IEEE Computer Society Press, pp530-541
Date: 1995
Report No.: CHACS-95-016

Abstract:

Integrity is usually considered to be at odds with security in multilevel databases. Integrity constraints enforce conditions on relations between data, while security constraints enforce separation between data. If an integrity constraint is defined over data at different security levels, a direct conflict results. However, the solution is not to sacrifice the integrity constraint altogether. Compromise solutions can often be found that guaranteed some, although not all, of the desired results of the constraint. In this paper, we will show that, by dividing the desired goals of integrity into three areas, consistency, correctness, and availability, one often find solutions to integrity problems that achieve some, if not all, of the goals without sacrificing security.

Title: Inference Problems in Multilevel Secure Database Management Systems
Author(s): Sushil Jajodia and Catherine Meadows
E-mail Address: meadows@itd.nrl.navy.mil
Citation: Information Security: An Integrated Collection of Essays (ed. M. Abrams, S. Jajodia, and M. Podell), IEEE Computer Society Press, pp570-584
Date: 1995
Report No.: CHACS-95-017

Abstract:

Inference is the process of deriving new information from known information. In multilevel database systems, the inference problem refers to the fact that the derived information can have higher sensitivity than the lower sensitivity of the information provided to the user by the system. This essay provides a survey of the state-of-the-art in the study of inference problems. It defines and characterizes the inference problem as it relates to multilevel database systems and describe methods that have been developed for dealing with it.

Title: The Role of Trust in Information Integrity Protocols
Author(s): Gustavus Simmons and Catherine Meadows
E-mail Address: meadows@itd.nrl.navy.mil
Citation: Journal of Computer Security, v3, n1, pp71-84
Date: 1995
Report No.: CHACS-95-018

Abstract:

Paradoxically, one of the most important – and at the same time, probably one of the least understood – functions performed by information integrity protocols is to transfer trust from where it exists to where it is needed. Initially in any protocol, there are at least two types of trust: trust that designated participants, or groups of participants, will faithfully execute their assigned function in the protocol and trust in the integrity of the transfer mechanism(s) integral to the protocol. Consequently, almost all protocols enforce a set of restrictions as to who may exercise them – either spelled out explicitly or left implicit in the protocol specification. In addition there may be unanticipated or even unacceptable groupings of participants who can also exercise the protocol as a result of actions taken by some of the participants reflecting trusts that exist among them. Formal methods are developed to analyze trust as a fundamental dimension in protocol analysis and proof.

Title: The Modulated-Input Modulated-Output Model
Author(s): Ira S. Moskowitz and Myong H. Kang
E-mail Address: moskowitz@itd.nrl.navy.mil or mkang@itd.nrl.navy.mil
Citation: Proceedings of IFIP WG11.3 (Database Security), pp61-75
Date: August 1995
Report No.: CHACS-95-019

Abstract:

In this paper we discuss why message acknowledgments are an appropriate engineering approach to meet system functionality. The data replication problem in database systems is our motivation. We introduce a new queuing theoretic model, the MIMO model, that incorporates burstiness in the sending side and busy periods in the receiving side. Based on simulation results derived from this model, we show that the buffer requirements from M/M/1/N queues are too optimistic.

Title: Reduction of a Class of Fox-Wright Psi Functions for Certain Rational Parameters
Author(s): Allen R. Miller and Ira S. Moskowitz
E-mail Address: moskowitz@itd.nrl.navy.mil
Citation: Computers & Mathematics with Applications, v30, n11, pp73-82
Date: 1995
Report No.: CHACS-95-020

Abstract:

The Fox-Wright Psi function is a special case of Fox's H-function and a generalization of the generalized hypergeometric function. In the present paper we show that the Psi function reduces to a single generalized hypergeometric function when certain of its parameters are integers and to a finite sum of generalized hypergeometric functions when these parameters are rational numbers. Applications to the solution of algebraic trinomial equations and to a problem in information theory are provided. A connection with Meijer's G-function is also discussed.

Title: A Network Version of the Pump

Author(s): Myong H. Kang, Ira S. Moskowitz, and Daniel C. Lee

E-mail Address: mkang@itd.nrl.navy.mil or moskowitz@itd.nrl.navy.mil or lee@kingcrab.nrl.navy.mil

Citation: Proceedings of the 1995 IEEE Symposium on Security & Privacy, pp144-154, Oakland, CA

Date: May 8-10, 1995

Report No.: CHACS-95-021

Abstract:

A designer of reliable MLS networks must consider covert channels and denial of service attacks in addition to traditional network performance measures such as throughput, fairness, and reliability. In this paper we show how to extend the NRL data Pump to a certain MLS network architecture in order to balance the requirements of congestion control, fairness, good performance, and reliability against those of minimal threats from covert channels and denial of service attacks. We back up our claims with simulation results.

Title: Assurance Mappings, a Chapter of the Handbook for the Computer Security Certification of Trusted Systems

Author(s): J. McHugh, C.N. Payne and C. Martin

E-mail Address: mchugh@itd.nrl.navy.mil

Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5540-- 95-081A

Date: January 24, 1995

Report No.: CHACS-95-022

Abstract:

The definition of an "appropriate fashion" comes from the system's security policy, and from security requirements which are detailed in the descriptive top-level specification (DTLS). The detailed information necessary to convince the evaluators that a system can be trusted to manage sensitive data is provided in the form of an assurance mapping between the trusted computing base (TCB), which implements the security related functions, and the security policy, which defines the secure behavior of those functions. The job of the developers is to sell the trustworthiness of the system to the evaluators using these mappings by

making a convincing argument that the TCB correctly enforces the security policy. In other words, the developer must convince the evaluators that the physical machine embodied in the TCB is an accurate simulation of the true, abstract machine prescribed the security policy. The abstract machine is first described in the Security Policy Model.

This chapter identifies the certification goals for the assurance mappings. Unlike other certification deliverables, the assurance mappings are generated throughout the development life cycle. They are a collection of documents rather than a single document, and a member of the collection may be part of another certification deliverable, such as the Security Policy Model. The developer must present the mappings as a coherent whole. This chapter also describes methods that can be used to hand-examine the code for minimality, because the TCSEC also requires the TCB to be "minimized" in the sense that it contains nothing not required to correctly implement the security-related functions. Proving that this requirement has been met is very difficult to do.

Title: Security Policy Model, a chapter of the Handbook for the Computer Security Certification of Trusted Systems
Author(s): Charles N. Payne
Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5540-- 95-080A
Date: January 24, 1995
Report No.: CHACS-95-023

Abstract:
The security policy model (SPM) is the apex of the assurance argument in the development of a trustworthy system. A system is trustworthy if the probability of a catastrophic flaw remaining after testing and review is acceptably low. In our case the correct behavior is described informally in a security policy. The SPM presents the constraints of the security policy in a way that can be analyzed formally. It guides the developer toward a secure design and implementation and helps the developer demonstrate rigorously that the system enforces its security policy. The SPM describes the system's security-relevant behavior for the user. Without the SPM, the security-relevant goals of the system are not well-defined for the developer, the user, or the evaluator. The SPM expresses the definition of security for a trusted system.

In this chapter, we instruct the evaluator in the assessment that an SPM fulfills the purposes identified above. We identify the structure of an SPM and guide the evaluator in the analysis of the structure. The SPM is influenced heavily by the critical requirements of the relationships between those entities. We discuss one way to determine if the appropriate entities and relationships have been modeled and if the critical requirements on those entities have been satisfied. We do not try to determine what constitutes a good definition of security for a trusted system. References are provided on this topic. Much research has been performed already regarding good definitions of security. We concentrate on the evaluation of the structures in the SPM that support the definition of security.

Title: The Epistemic Representation of Information Flow Security in Probabilistic Systems

Author(s): Paul F. Syverson and James W. Gray

E-mail Address: syverson@itd.nrl.navy.mil

Citation: Proceedings of the Eighth IEEE Computer Security Foundations Workshop (CSFW8), IEEE CS Press, pp152-166

Date: June 13-15, 1995

Report No.: CHACS-95-024

Abstract:

We set out a logic for reasoning about multilevel security of probabilistic systems. This logic includes modalities for time, knowledge, and probability. In earlier work we gave syntactic definitions of multilevel security and showed that their semantic interpretations are equivalent to independently motivated information-theoretic definitions. This paper builds on that earlier work in two ways. First, it substantially recasts the language and model of computation into the more standard Halpern-Tuttle framework for reasoning about knowledge and probability. Second, it brings together two distinct characterizations of security from that work. One was equivalent to the information-theoretic security criterion for a system to be free of covert channels but was difficult to prove. The other was a verification condition that implied the first; it was more easily provable but was too strong. This paper presents a characterization that is syntactically very similar to our previous verification condition but is proven to be semantically equivalent to the security criterion. The new characterization also means that our security criterion is expressible in a simpler logic and model.

Title: Fail-Stop Protocols: An Approach to Designing Secure Protocols

Author(s): Li Gong and Paul F. Syverson

E-mail Address: syverson@itd.nrl.navy.mil

Citation: Fifth International Working Conference on Dependable Computing for Critical Applications (DCCA-5), pp44-55

Date: September 27-29, 1995

Report No.: CHACS-95-025

Abstract:

We present a methodology to facilitate the design and analysis of secure cryptographic protocols. We advocate the general approach, and a new avenue for research, of restricting protocol designs to well-defined practices, instead of ever increasing the complexity of protocol security analysis mechanisms to deal with every newly discovered attack and the endless variations in protocol construction. In particular, we propose a novel notion of a fail-stop protocol, which automatically halts in response to any active attack that interferes with protocol execution, thus reducing protocol security analysis to that of passive attacks only. We suggest types of protocols that are fail-stop, outline some proof techniques for them, and use examples to illustrate how the notion of a fail-stop protocol can make protocol design easier and can provide a more solid basis for some available protocol analysis methods.

1994 PUBLICATIONS

CHACS-94-001 Confidentiality in a Replicated Architecture Trusted Database System: A Formal Model, *O. Costich, J. D. McLean, and J. P. McDermott*

CHACS-94-002 The SINTRA Data Model: Structure and Operations, *O. Costich, M. H. Kang, and J. N. Froscher*

CHACS-94-003 A Practical Approach to High Assurance Multilevel Secure Computing Service, *J. N. Froscher, M. H. Kang, J. P. McDermott, O. Costich, and C. E. Landwehr*

CHACS-94-004 Multiple-query Optimization at Algorithm-level, *M. H. Kang, H. Dietz, and B. Bhargava*

CHACS-94-005 Architectural Impact on Performance of a Multilevel Database System, *M. H. Kang and J. N. Froscher*

CHACS-94-006 Achieving Database Security through Data Replication: The SINTRA Prototype, *M. H. Kang, J. N. Froscher, J. P. McDermott, O. Costich, and R. Peyton*

CHACS-94-007 Using Object Modeling Techniques To Design MLS Data Models, in Security for Object-Oriented Systems, *M. H. Kang, O. Costich, and J. N. Froscher*

CHACS-94-008 A Taxonomy of Computer Program Security Flaws, with Examples, *C. E. Landwehr, A. R. Bull, J. P. McDermott, and W. S. Choi*

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CHACS-94-018 A Model of Computation for the NRL Protocol Analyzer, *C.A. Meadows*

CCHAS-94-019 Three Systems for Cryptographic Protocol Analysis, *R. Kemmerer, C.A. Meadows, and J. Millen*

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CHACS-94-035 The Generalized Railroad Crossing: A Case Study in Formal Verification of Real-Time Systems, *C.L. Heitmeyer and N. Lynch*

CHACS-94-036 The Role of HCI in CASE Tools Supporting Formal Methods, *C.L. Heitmeyer*

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CHACS-94-038 Design Documentation for the SINTRA Preprocessor, *Myong H. Kang and Rodney Peyton*

1993 PUBLICATIONS

CHACS-93-001 A Practical Transaction Model and Untrusted Transaction Manager for a Multilevel-Secure Database System, *Myong H. Kang, Oliver Costich, and Judith N. Froscher*

CHACS-93-002 Orange Locking: Channel-Free Database Concurrency Control via Locking, *John P. McDermott and Sushil Jajodia*

CHACS-93-003 A Logical Language for Specifying Cryptographic Protocol, *Paul F. Syverson*

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CHACS-93-005 On Analyzing the Bus-Contention Channel Under Fuzzy Time, *James W. Gray, III*

CHACS-93-006 Comparing Different Approaches for Specifying and Verifying Real-Time Systems, *C. Heitmeyer, R. Jeffords and B. Labaw*

CHACS-93-007 Toward a Comprehensive INFOSEC Certification Methodology, *Charles N. Payne, Jr., Judith N. Froscher and Carl E. Landwehr*

CHACS-93-008 Panel on Cryptographic Protocol Models and Requirements, *Paul F. Syverson*

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CHACS-93-014 An International Survey of Industrial Application of Formal Methods: Case Studies, *D. Craigen, S. Gerhart, T. Ralston*

CHACS-93-015 Maintaining Multilevel Transaction Atomicity in MLS Database Systems with Kernelized Architecture, *Oliver Costich and Sushil Jajodia*

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CHACS-93-027 COMPUSEC, A Personal View, *Herman O. Lubbes*

CHACS-93-028 Adding Time to a Logic of Authentication, *Paul F. Syverson*

CHACS-93-029 Toward a Mathematical Foundation for Information Flow Security, *James W. Gray, III*

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CHACS-93-030 Knowledge, Belief, and Semantics in the Analysis of Cryptographic Protocols, *Paul F. Syverson*

CHACS-93-031 TAMPS Key Manager Functional Requirements, *Matthew J. Fierst*

V. TRANSMISSION TECHNOLOGY

CODE 5550

The Transmission Technology (TT) Branch conducts a research and development program directed toward the improvement of information transmission and reception between surface, air, submerged and space platforms. The Branch mission includes understanding and developing approaches to satisfy the need for affordable, efficient and robust dissemination of combat management information. In support of this goal, the Branch investigates all aspects of the process of information transfer including the development of state-of-the-art transmission equipment as well as research into antennas and channel propagation phenomena. Emphasis is placed on those aspects of transmission technology that permit adaptation to inhospitable natural or man-made environments. In addition, the Branch conducts research and development in support of signal intercept and related intelligence system projects. Areas of activity include: (1) wideband HF architecture and RF system engineering; (2) communication channel characterization including Arctic communication issues; (3) intercept system analysis, development, and prototype evaluation; (4) satellite and space communication technology; and (5) research into wideband and compact antenna systems.

Title: Delay, Doppler, and Amplitude Characteristics of HF Signals Received Over a 1300-km Transauroral Skywave Channel

Author(s): Leonard S. Wagner, Joseph A. Goldstein, Michael A. Rupar, and Edward J. Kennedy

E-mail Address: wagner@itd.nrl.navy.mil, rupar@itd.nrl.navy.mil, kennedy@itd.nrl.navy.mil

Abstract:

Channel-probe observations of propagation conditions along a 1294-km transauroral path between Sondrestrom, Greenland and Keflavik, Iceland were made during the period from 13 March to 2 April 1992. The midpoint of this path was located at a corrected geomagnetic latitude of 72°. The objective of these measurements was to supplement the existing data base describing propagation conditions on the HF transauroral channel with data pertaining to a period around the time of solar maximum. Received signals for this path fell into three distinct groups depending on their amplitude and delay-Doppler spread characteristics. These are: (1) strong, specularly reflected ionospheric returns characteristic of a quiescent daytime ionospheric channel during magnetically quiet conditions; (2) strong specular multipath signals reflected from horizontal gradients of electron density and regularly encountered at night; and (3) weak scatter returns that are also a persistent nighttime phenomenon. The scatter returns are usually observed at delays exceeding those anticipated for the one hop return and, very often, at frequencies that are well above the MUF for the great circle propagation path. The multipath and scatter returns exhibit large delay and Doppler spreads indicative of spatially extensive distributions of drifting and randomly moving irregularities. Two measurement events are discussed which illustrate these conclusions: a noontime measurement with K_p - 3, and a midnight measurement with K_p - 2.

The noontime measurement exhibited a scatter return from an isolated irregularity region in addition to the usual ionospheric reflected signals. A simple irregularity drift model produced delay and Doppler-shift curves that were consistent with those observed for the scatter component of the received signal and supported a hypothesis of an irregularity region drift speed of 1200 m/s parallel to the great circle propagation path.

Title: Channel Spread Parameters for the High-Latitude, Near-Vertical-Incidence-Skywave HF Channel: Correlation with Geomagnetic Activity

Author(s): Leonard S. Wagner and Joseph A. Goldstein

E-mail Address: wagner@itd.nrl.navy.mil

Abstract:

Results of measurements on a high-latitude, near-vertical-incidence, HF skywave channel are presented. The measurements are for a time period (May 1988), roughly two years after the peak of solar cycle #22, when the mean sunspot number was 85. The measurement periods include day, afternoon, night, and early morning times and cover a wide range of geomagnetic disturbance conditions. Signal amplitude, delay-spread and Doppler-spread are the channel characteristics of primary interest. The correlation of these channel characteristics with geomagnetic activity and with the position of the propagation path relative to selected regions of the auroral zone are examined. Ionogram characteristics for all measurements are briefly reviewed in light of geomagnetic and geographic factors. Four selected cases, representative of magnetically quiet nighttime conditions, and magnetically active nighttime conditions are examined in detail. The measurement results indicate that, depending on geomagnetic and geographic factors, the received signals may be the result of simple reflection from a smoothly varying ionosphere, multipath reflection from an irregular ionosphere, or scattering (or a combination of multipath reflection and scattering) from an irregular ionosphere. Signals for the four groups are shown to be readily distinguishable on the basis of their characteristics and provide an estimate of the range of values of Doppler-spread and spread-factor that may be expected on the channel.

Abstract:

Pitch-synchronous segmentation (PSS) of speech is a procedure for excising a speech waveform of one pitch period. Synthesis involves replicating the segmented waveform. By means of interpolation, one pitch waveform can generate up to three or four consecutive pitch waveforms without introducing audible speech degradation. In this paper, we present a 2.4-kb/s vocoder which transmits, among others, the speech spectrum of one pitch period. The spectrum is first approximated by an all-pole spectrum then further refined by a remnant spectrum. The performance of this vocoder operating at 2.4 kb/s compares favorably with 4.8-kb/s CELP.

Abstract:

The focus in this paper is on protocol usage in wide-area networks based on the Asynchronous Transfer Mode (ATM) protocols. Local usage of ATM switches to emulate local-area networks is an emerging technology that is expected to alter protocol use in the future, but in the interim and for the near term, protocol usage in wide-area networks is expected to be based on a hybrid of well-established protocol suites overlayed on commercial and private wide-area networks built up of ATM switches. This paper is intended to address low-level questions of protocol structure, providing a compilation for network managers of the characteristics and detailed structure of protocols that might be observed on ATM WANs. Of particular interest is the identification of protocol profiles that might exist in ATM WANs, i.e., combinations of protocols to support computer communications that are popular, commercially available, or at least viable.

1994 PUBLICATIONS

TT-94-001 Enhancement of Stimulated Electromagnetic Emission during Two Frequency Ionospheric Heating Experiments, *Paul A. Bernhardt, Leonard S. Wagner, Joseph A. Goldstein, et al.*

TT-94-002 Correlation of High Latitude Ionospheric Disturbances with Geomagnetic Activity, *Leonard S. Wagner and Joseph A. Goldstein*

TT-94-003 Encoded Speech Intelligibility Improvement in the F/A-18 Noise Environment Using Spectral Subtraction Preprocessing, *David A. Heide*

TT-94-004 Arctic Propagation Phenomena at VHF and UHF for a BLOS Path, *Edward J. Kennedy and Michael A. Rupar*

TT-94-005 Speech Analysis and Synthesis Based on Pitch-Synchronous Segmentation of the Speech Waveform, *George S. Kang and Lawrence J. Fransen*

TT-94-006 Electromagnetic Spectrum Occupancy Study of a Potential Transmitter Site for the HF Active Auroral Research Program (HAARP), *Joseph A. Goldstein, Edward J. Kennedy and Monroe Y. McGown*

TT-94-007 A Laboratory Prototype HF Repeater for Relocatable Over-the-Horizon-Radar, *Adrian S. Eley*

TT-94-008 TESPEX 2: Data Telemetry and Acquisition, *Timothy L. Krout , Jon Jannucci, Joseph Goldstein, et al.*

1993 PUBLICATIONS

TT-93-001 An Electromagnetic Interference Study of Potential Transmitter Sites for the HF Active Auroral Research Program (HAARP), *Joseph A. Goldstein, Edward J. Kennedy, Adrian S. Eley and Michael A. Rupar*

TT-93-002 Morphology and Characteristics of Disturbed HF Skywave Channels, *Leonard S. Wagner*

TT-93-003 Performance of Adaptive Interference Cancellation in Reducing VHF Interference, *Adrian S. Eley and John B. Wood*

TT-93-004 Northern Exposure 92: An Investigation of Transauroral HF Radio Skywave Propagation, *Leonard S. Wagner, Joseph A. Goldstein, Michael A. Rupar and Edward J. Kennedy*

TT-93-005 Morphology and Characteristics of Disturbed HF Skywave Channels, *Leonard S. Wagner*

VI. ADVANCED INFORMATION TECHNOLOGY

CODE 5580

The Advanced Information Technology (AIT) Branch of the Information Technology Division develops and implements cutting edge hardware and software solutions or Navy problems in a number of application areas. Current research and development thrusts include:

- parallel and distributed hardware, software and display technologies;

- novel signal processing techniques directed primarily toward the exploitation of massively parallel systems;

- development of hardware-independent systems for developing and porting code for parallel processing systems;

- design and implementation of reactive and interactive control systems;

- development of technologies for decision support systems and prototyping of all varieties of decision systems including tactical decision aids and mission planning;

- exploration and demonstration of new methods for data management including data fusion, design and navigation of database systems, and correlation and tracking of current and historical information; and display technologies for visual management of all of the above applications.

The technical programs in the Branch include some basic research (6.1), a substantial exploratory development program (6.2) and a continuing effort to field technology through a succession of advanced technology demonstrations (6.3a). The Branch draws on expertise in computer science, mathematics, operations research, electrical engineering and physics.

Title: Reconstruction and Visualization of Underwater Objects from High-Resolution Acoustic Lens Data

Author(s): Behzad Kamgar-Parsi and Bruce Johnson
E-Mail Address: behzad@ait.nrl.navy.mil

Abstract

We present images taken by two systems designed for high-resolution, close-up underwater acoustic imaging. The imaging systems use an acoustic lens to focus incoming waves. One of the systems has fan shaped beams and is used to take 2D images, the other system with conical shaped beams is used foe 3D imaging. We discuss the techniques used for processing the acoustic backscatter data, reconstructing the scene, enhancing and visualizing objects. The images show a remarkable degree of detail. The conical-beam images, in particular, are of sufficiently high quality that they may be used in building a reliable automatic object recognition system.

Title: Finite-Difference Time-Domain Simulations of Wave Propagation and Scattering as a Research and Educational Tool

Author(s): J. B. Cole, R. A. Krutar, S. K. Numrich, and D. B. Creamer
E-Mail Address: cole@ait.nrl.navy.mil

Abstract

In this paper we introduce the finite-difference time-domain (FDTD) method to solve the wave equation. The FDTD algorithm is a useful tool to study wave propagation and scattering processes because the wave fields, which are computed at each time step, can be displayed to produce animated visualization during the computation. The FDTD algorithm is simple to implement, easily parallelizable, and well suited to solving wave propagation and scattering problems with complicated boundaries and non-uniform media. In the FORTRAN 90 programming language the basic code is only a few lines, and the computation time is independent of problem complexity. In this paper we derive the basic FDTD algorithm and reinterpret it in terms of an interacting cell model and heuristically derive various features that normally require detailed analysis. Finally we show how to implement boundary conditions at the subgrid level.

Title: Technical Documentation of Nodestar
Author(s): Lawrence D. Stone, Thomas L. Corwin, and James B. Hofmann
E-Mail Address: hofmann@ait.nrl.navy.mil
Citation: Naval Research Laboratory Formal Report, NRL/FR/5580--95-9788
Date: December 11, 1995
Report No.: AIT-95-003

Abstract

A general framework for the process of multiple target, multiple sensor data fusion is described. With that framework in place, those areas in which the methodology is mature and ripe for implementation and those areas that require further development are identified. One area in which the methodology is well advanced is non-linear tracking. For that area a basic engine, Nodestar, which has been developed to perform non-linear, multiple-target tracking is described. Then the version of Nodestar that has been developed for the Spotlight Advanced Technology Demonstration is described. A discussion of extensions to this version of Nodestar is also included.

Title: Distribution And Moments Of The Weighted Sum Of Uniform Random Variables, With Applications In Reducing Monte Carlo Simulations
Author(s): Behzad Kamgar-Parsi, Behrooz Kamgar-Parsi and Menashe Brosh
E-Mail Address: behzad@ait.nrl.navy.mil
Citation: Journal of Statistical Computation and Simulation, v52, pp399-414
Date: August 1995
Report No.: AIT-95-004

Abstract

We derive analytical expressions for the distribution function and the moments of the weighted sum $Y = \sum_{i=1}^{N} a_i X_i$ where X_i are independent random variables with non-identical uniform distributions, for an arbitrary number of variables N, and arbitrary coefficient values a_i. These results are the generalizations of those for the regular sum of uniform random variables. Using the results, we examine the inadequacy of the central limit approximation for finite N. We also discuss the savings in the cost of computing properties of the weighted sum using these results vs. Monte Carlo simulations. We give an example of the application of the weighted sum to analyzing the effects of digitization error in computer vision.

Title: Autonomous Battle Damage Assessment Study
Author(s): Tamara Luzgin
E-Mail Address: luzgin@ait.nrl.navy.mil
Citation: NRL Formal Interim Report, publication of abstract, Document Classified, Distribution Limited
Date: June 1995
Report No.: AIT-95-005

Abstract

The study is a research project tasked to identify a core set of measures of effectiveness that can be utilized to assess battle damage and to provide estimates of operational effectiveness in Space and Electronic Warfare (SEW) battlespace which targets adversarial command and control (C2) systems and information infrastructure. The approach recommended can be adapted to developing Battle Damage Assessment (BDA) for Information Warfare operations.

The study identifies the operational requirements for developing battle damage assessments of adversarial C2 systems and information infrastructure and specifies a common set of systemic and operational attributes that can be measured (observed) and that are sufficiently consistent to be exploited. The study concludes that BDA is as much a warfighting concept as it is a warfighting operation. BDA for the emerging battlespace is a tasked, interactive information collection and systems analysis process that supports a wide range of warfighting activities and battlespace environments. The study recommends that SEW BDA should be developed as a family of stand-alone systems of systems tailored for the battlespace. The kind of BDA employed is determined by systems, technology, weapons, warfighting mission, battlespace environment, and target sets. The study presents a technology roadmap and offers recommendations for leveraging critical technologies.

Title: A High Accuracy FDTD Algorithm to Solve Microwave Propagation and Scattering Problems on a Coarse Grid
Author(s): James B. Cole
E-Mail Address: cole@ait.nrl.navy.mil
Citation: IEEE Transaction on Microwave Theory and Techniques, v43, n9, pp. 2053-2058
Date: September 1995
Report No.: AIT-95-006

Abstract

If the spatial variation of electric permittivity and magnetic permeability is "small" Maxwell's equations can be approximated by the scalar wave equation in each field component. We introduce a new high-accuracy second order finite-difference time-domain (FDTD) algorithm to solve the scalar wave equation on a coarse grid with a solution error less than 10^{-4} that of the conventional one. The computational load at each grid point is greater, but it is more than offset by a large reduction in the number of grid points needed, as well as by a reduction in

the number of iterations. Also boundaries can be more accurately characterized at the subgrid level. Although optimum performance is achieved at a fixed frequency, the accuracy is still much higher than that of a conventional FDTD algorithm over "moderate" bandwidths

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Title: Tactical BDA for Space and Electronic Warfare (abstract only)
Author(s): Tamara Luzgin
E-Mail Address: luzgin@ait.nrl.navy.mil
Citation: MORSS book of Abstracts
Date: June 1995
Report No.: AIT-95-007

Abstract

The autonomous Battle Damage Assessment (BDA) study is a research project tasked to identify a core set of measures of effectiveness that can be used to assess battle damage and to provide estimates of operational effectiveness that can be used to assess battle damage and to provide estimates of operational effectiveness in a Space and Electronic Warfare (SEW) or joint battlespace where target sets include the adversary's command and control (C2) systems and segments of his information infrastructure. The study recommends an approach that is also suitable for developing BDA for Information Warfare operations.

The study identifies the operational and tactical requirements for assessing battle damage to the adversary's information infrastructure and his C2 systems. The study suggests a common set of systemic and operational attributes that can be observed and/or measured and that are sufficiently consistent to be exploited. The study concludes that BDA is a tasked, interactive information collection and systems analysis process that supports warfighting activities across a five dimensional battlespace. The study recommends that SEW BDA should be developed as a highly distributed hierarchic family of stand-alone systems of systems that is hosted on weapons, airborne platforms, and space-based battle managers and that is dynamically configured for the battlespace and the mission. The kind of BDA employed in the battlespace is determined by systems, technology, weapons, warfighting objectives, battlespace features, and target sets. The study presents a technology roadmap and offers recommendations for leveraging critical technologies.

Title: Threat Site Overflight Modeling for Strike Route Optimization
Author(s): Miguel R. Zuniga and Patrick Gorman
E-Mail Address: zuniga@ait.nrl.navy.mil
Citation: 12th Annual Conference on Command and Control Decision Aids
Date: June 1995
Report No.: AIT-95-008

Abstract

An important component of strike routing is modeling of the increased threat to strike assets as they repeat flights over threats. In one form or another, strike planners have taken this phenomenon into account since World War II. Initially, only rough estimates of the effect were considered, but even these improved aircraft survivability. Accurate modeling of this effect is desirable to provide better automatic (computer based) routing and reduce workload for strike planners. We discuss this problem, propose models for use in optimization, and discuss the limitations of modeling with graph theoretic techniques. In the process we present some general relations that are important in modeling with graphs whose edge traversal represent independent probabilistic events. We also present a new method for graph representation of the time dependence of these phenomena. Finally, the models and algorithms are considered in relation to single asset routing and joint routing of multiple assets.

Title: Hyperbolic Pattern Detection Using the Hough and Fourier Transform
Author(s): Becky Popp
E-Mail Address: popp@ait.nrl.navy.mil
Citation: IASTED International Conference on Signal and Image Processing (SIP-95) Proceedings, pp268-271
Date: November 20-23, 1995
Report No.: AIT-95-009

Abstract

Earlier research showed that an Extended Hough Transform is effective in detecting broadband multipath interference patterns in acoustic Lofargrams. By combining the Hough transform and the Fourier transform, the processing gain is improved. Broadband multipath interference patterns are formed on a Lofargram when signals are received via multiple paths from a broadband acoustic source moving with constant velocity and depth. An interference pattern can be closely approximated by a family of hyperbolas. The Hough transform is used to perform line integrations over candidate families of hyperbolas. After the transform, the Hough output data corresponding to the family of hyperbolas matching an interference pattern contains periodic components. The Fourier transform is performed over the Hough output data with resulting peak value(s) corresponding to the interference pattern(s). Resulting parameters provide information which can be used to aid in source location.

Title: Persistence in Computational Geometry
Author(s): Ali R. Boroujerdi
E-Mail Address: boroujerdi@ait.nrl.navy.mil
Citation: Canadian Conference on Computational Geometry
Date: August 10, 1995
Report No.: AIT-95-010

Abstract

We show how persistence can be used to solve a number of geometric problems where preprocessing is required to facilitate query answering. Efficient solutions for most of the problems discussed already exist in the literature; however, persistence provides an efficient and conceptually simpler alternative to existing solution.

Title: Virtual Reality Unbound
Author(s): Larry Rosenblum, Guest Editor
E-Mail Address: rosenblum@ait.nrl.navy.mil
Citation: IEEE Computer Graphics and Applications
Date: 1995
Report No.: AIT-95-011

Abstract not available. Monthly column.

Title: Virtual Reality, Visualization and Their Application
Author(s): Rae E. Earnshaw and Lawrence J. Rosenblum
E-Mail Address: rosenblum@ait.nrl.navy.mil
Citation: Proceedings of Interface 95
Date: 1995
Report No.: AIT-95-012

Abstract

One of the major tasks in scientific investigation is analyzing data and extracting the results. Often there are large amounts of data and coping with the volume can be a difficult task. A new result can be buried in data values like a needle in a haystack. Effective visualization tools are now available for exploring data sets and locating regions of interest, often interactively and in real time. Powerful desk-top computers coupled with scientific visualization techniques enable the scientist to analyze data in powerful and flexible ways. Having software tools to explore data domains has now refocussed attention back on the human interface and the method by which humans can interact with large data sets in optimum and effective ways. Virtual Reality (VR) has been used to enable the user to literally explore the data space and gain an intuitive feel for the properties and relationships in the data. Workstation screens and keyboards enable a user to observe the picture. Virtual reality tools put the user 'in the picture.' Initial results indicate that this is a quantitative leap forward in the potential for data exploration and extraction of meaningful results. This article reviews some of the current facilities now available and their current and potential application areas.

Title: Interactive Realism for Visualization Using Ray Tracing
Author(s): Robert A. Cross
E-Mail Address: cross@ait.nrl.navy.mil
Citation: IEEE Visualization 95' Conference Proceedings
Date: November 1995
Report No.: AIT-95-013

Abstract

Visualization realism is necessary for many virtual reality applications. In order to convince the user that the virtual environment is real, the scene presented should faithfully model the expected actual environment. A highly accurate, fully modeled, interactive environment is thus seen as "virtually real." This paper addresses the problem of interactive visual realism and discusses a possible solution: a hybrid rendering paradigm that ties distributed graphics hardware and ray tracing systems together for use in interactive, high visual realism applications.

This new paradigm is examined in the context of a working rendering system. This system is capable of producing images of higher fidelity than possible through the use of graphics hardware alone, able both to render images at speeds useful for interactive systems and to progressively refine static, high quality snapshots.

Title: Infrastructure for Rapid Execution of Strike-Planning Systems
Author(s): James B. Hofmann, John Cleary, Darrin West, Larry Mellon and Jim Ramsey
E-Mail Address: hofmann@ait.nrl.navy.mil
Citation: Proceedings of Winter Simulation Conference (WSC)
Date: December 3-6, 1995
Report No.: AIT-95-014

Abstract

A rapid-planning system for military aircraft strikes is under design. It is intended to be capable of creating aircraft routes through enemy and friendly space with minimum loss of aircraft and maximal damage to specified target areas. The system must support joint strike planning, where the effects of several simultaneous strikes by differing groups of aircraft are captured.

This paper describes a three-phased approach to the analysis of routes: static analysis to establish potential routes, detailed simulation to capture dynamic behaviors in the system, and human-in-the-loop evaluation of the most promising routes.

A parallel, discrete event simulation technique is proposed to support the detailed simulation. Optimization based on application characteristics are described. A technique to combine discrete-event and time-stepped models is proposed. Performance results of the current simulation engine are given.

Title: Effectiveness of Various New Bandwidth Reduction Techniques in ModSAF
Author(s): Kevin L. Russo, Lawrence C. Schuette, Ph.D., Joshua E. Smith and Matthew McGuire
E-Mail Address: schuette@ait.nrl.navy.mil
Citation: Proceeding of the 13th Workshop on Standards for the Interoperability of Distributed Simulation
Date: September 19, 1995
Report No.: AIT-95-015

Abstract

We have been working on techniques to improve the scalability of DIS applications. These techniques include multicast UDP/IP, bundling of PDUs, efficient encoding within PDU's, and quiescent object services. These techniques are being developed by the Realtime Information Transfer Networking (RITN) team as part of the ARPA STOW-97 ACTD. This paper will exam the effectiveness of these techniques to reduce DIS packet rates and the network bandwidth requirements for STOW-97. Some preliminary results will be presented.

At the 12th DIS conference we presented preliminary results of our work in the area of multicast. In this paper we will present more extensive results demonstrating savings in both network B/W and simulator CPU cycles achieved by using multicast.

Bundling of PDUs is allowed by the DIS protocols, and has been implemented as an option in ModSAF, a widely used CGF system. Here we present results showing the effects of combining multicast and bundling.

Efficient encoding is a technique whereby the DIS PDU is restructured to eliminate unneeded or unchanging data as required. We will show the bandwidth reduction for typical exercises as compared to standard PDU structure.

Finally, we will show the effect of a Quiescent Object protocol. Software detects when objects are quiescent, and uses a different mechanism (not Entity State PDUs) to communicate those entities. Fewer PDUs are transmitted and the network load is reduced. Network measurements showing the B/W and packet rate reduction will be shown for typical exercises.

Title: Network Routing Models Applied to Aircraft Routing Problems
Author(s): Zhiqiang Chen, Andrew T. Holle, Bernard M.E. Moret, Jared Saia, and Ali Boroujerdi
E-Mail Address: boroujerdi@ait.nrl.navy.mil
Citation: Proceeding of the Winter Simulation Conference
Date: December 3-6, 1995
Report No.: AIT-95-016

Abstract

We study network models applied to two aircraft routing problems, one in which the goal is to route strike aircraft to a target and back so as to minimize

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losses and one in which the goal is to route civilian traffic around an airport so as to minimize noise exposure of the population. We propose joint routing as our model: find a required number of time-disjoint routes in a network that minimized the total cost. We show that joint routing can in turn be modeled as a dynamic network flow problem. We study this problem under several variants and on different types of networks, establishing tight bounds on the running time of exact solutions through applications of both existing and some new methods. We also discuss modeling of the airspace in which the routing takes place and how choices affect the performance of our optimization algorithms. Our model extends to other applications, such as the routing of hazardous materials and of secure communications.

Title: High Accuracy Solution of Maxwell's Equations Using Non-Standard Finite Differences
Author(s): James B. Cole
E-Mail Address: cole@ait.nrl.navy.mil
Citation: Submitted to: Computers in Physics
Date: December 19, 1995
Report No.: AIT-95-017

Abstract

We introduce a new finite-difference time-domain algorithm to directly solve Maxwell's equations based on non-standard finite differences. This algorithm is some 10,000 times more accurate than the standard one on a coarse grid. Although computational load per grid point is greater, it is more than offset by a large reduction in the total number of grid points needed to solve a given problem. In addition, algorithm stability is greater so that the number of iterations needed is also reduced. While optimum performance is achieved at a fixed frequency, the accuracy is still higher than that of the standard algorithm over "moderate" bandwidths.

We have implemented the algorithm in FORTRAN 90 and can easily model spatially variant media and irregular boundaries. By displaying one or more fields per waveperiod we obtain on-line movie-like visualizations of the electromagnetic fields while the computation is running.

Title: Coding and Compression with Flexible Transform
Author(s): Behzad Kamgar-Parsi, Behrooz Kamgar-Parsi and Lawrence C. Schuette
E-Mail Address: behzad@ait.nrl.navy.mil
Citation: IASTED Signal and Image Processing Conference Proceedings
Date: November 20-23, 1995
Report No.: AIT-95-018

Abstract

Flexible transforms represent the data in terms of a set of flexible basis functions, i.e. functions with adjustable parameters. These transforms are more powerful than fixed transforms in coding signals, nevertheless they are seldom used in practice. This is because the computation of a flexible transform involves solving a nonlinear optimization problem. In this paper, we suggest a recipe for computing flexible transforms. Flexible transforms and 2-layer neural networks are closely related. Computation of flexible transforms is equivalent to learning the signal with the network. We use the corresponding fixed transform to construct the network and initialize its weights. Empirical evidence suggests that this procedure yields optimum solutions.

Title: Virtual Reality: Research Issues and Applications
Author(s): Robert A. Cross and Lawrence J. Rosenblum
E-Mail Address: cross@ait.nrl.navy.mil
Citation: British Computer Society Conference Proceeding on Modeling and
  Visualization
Date: December 5-7, 1995
Report No.: AIT-95-019

Abstract

Virtual reality (VR) is a demanding computer science research field. This paper discusses important problems faced in current virtual reality research in its attempts to provide interaction, visual realism, and multimodal immersion. We also examine selected applications to provide a sense of what is achievable today in VR and the directions in which the field is heading.

Title: Persistent Linked Structures at Constant Worst-Case Cast
Author(s): Ali R. Boroujerdi and Bernard M.E. Moret
E-Mail Address: boroujerdi@ait.nrl.navy.mil
Citation: Information Processing Letter
Date: 1995
Report No.: AIT-95-020

Abstract

We present a method for making linked structures with nodes of in-degree not exceeding 1 partially persistent at a worst-case time cost of $O(1)$ per access step and a worst-case time and space cost $O(1)$ per update step.

Title: Estimating the Effective Depth of Laser Imaging Systems In Various
  Ocean Environments
Author(s): Jerry L. Gorline
E-Mail Address: gorline@ait.nrl.navy.mil
Citation: Interim Report
Date: October 23, 1995
Report No.: AIT-95-021

Abstract

In this paper we present the results of running Monte Carlo simulations on the Connection Machine (CM-5E) to study the behavior of laser propagation in the ocean. We developed an advanced hydrologic radiative transfer model to estimate the effective depth of a laser imaging system in various ocean environments. This model simulates a flat ocean surface. The effective depth is defined as that at which a six-pixel wide disk target can no longer be detected in the upward irradiance field at the ocean surface. Simulations showed that the effective depth was inversely proportional to the total attenuation coefficient.

1994 TECHNICAL REPORTS

AIT-94-001 Determinacy of Generalized Schema II, *Richard S. Stevens*

AIT-94-002 Time-Domain Visualization of Electromagnetic and Acoustic Wave Fields Computed with a Cellular Automaton Algorithm on a Parallel Computer, *James B. Cole, Rudolph A. Krutar and Susan K. Numrich*

AIT-94-003 Visualizing Noisy Underwater Acoustic Range Images, *Behzad Kamgar-Parsi and Behrooz Kamgar-Parsi*

AIT-94-004 A Prototype System for the Evaluation of Interdependent Routing Algorithms for Military Aircraft, *Ranjeev Mittu*

AIT-94-005 Advanced Technology for Precision Strike Planning, *James B. Hofmann and Dennis Carroll*

AIT-94-006 Weapon-Target Allocation for Force-Level Strike Planning, *Ray Jakobovits, Dennis Carroll Metron and James Hofmann*

AIT-94-007 High-Resolution Underwater Acoustic Imaging, *Behzad Kamgar-Parsi*

AIT-94-008 Progress and Problems in Ocean Visualization, *Lawrence J. Rosenblum and Behzad Kamgar-Parsi*

AIT-94-009 Challenges in the IV&V of C2E Software, *Dr. Kurt Askin, Kenneth W. Pitts, James E. Coolahan, et al.*

AIT-94-010 European Activities in Virtual Reality, Jose *Encarnacao, Matin Gobel and Lawrence Rosenblum*

AIT-94-011 Support Tools for the Processing Graph Method, *Roger Hillson*

AIT-94-012 Using the Hough Transform and the Fourier Transform to Detect Broadband Multipath Interference Patterns in Lofargram Images, *Becky Popp*

AIT-94-013 Cyberpower 2000: The Information Revolution, *Tamara Luzgin*

AIT-94-014 A Nearly Exact Second Order Finite-Difference Time-Domain Wave Propagation Algorithm on a Coarse Grid, *James B. Cole*

AIT-94-015 Data Consolidation and Connected Components, *Joseph B. Collins*

AIT-94-016 Observation on Operational Jointness, *Tamara Luzgin*

AIT-94-017 Research Issues in Scientific Visualization, *L. Rosenblum, Guest Editor*

AIT-94-018 Research Issues in Volume Visualization, *Arie Kaufman, Karl Heinz Hohne, Wolfgang Kruger, et al.*

AIT-94-019 Visualization Blackboard Department, *L. J. Rosenblum, Editor*

1993 PUBLICATIONS

AIT-93-001 A Cellular Automaton Methodology for Solving the Wave Equation, *J. B. Cole, R. Krutar, D. B. Creamer, and Susan K. Numrich*

AIT-93-002 A Nearly Exact Second Order Finite Difference Wave Propagation Algorithm on a Coarse Grid, *James B. Cole*

AIT-93-003 A Cellular Automaton Algorithm for Time-Domain Simulation and Visualization of Wave Propagation, *J. B. Cole, R. A. Krutar, D. B. Creamer and S. K. Numrich*

AIT-93-004 Neural Networks: An NRL Perspective, *Chip Backmann, Paul Bey, Jeremy Broughton, Victor Chen, Sheldon Gardner, Behrooz Kamgar-Parsi, Behzad Kamgar-Parsi, Moon Kim, Francis Kub, Keith Moon, Abraham Schultz, John Sciortino, Dean Scribner, Andrew Skinner, William Tolles, Jeff Willey and Sheldon Wolk*

AIT-93-005 Undersea Visualization: a Tool for Scientific and Engineering Progress, *L. J. Rosenblum, W. K. Stewart, and Behzad Kamgar-Parsi*

AIT-93-006 3D Acoustic Imaging with a Thin Lens, *B. Johnson, D. Scroggins, D. Folds, Behzad Kamgar-Parsi and E. Belcher*

AT-93-007 A Revised Clustering Technique Using a Hopfield Network, *Behzad Kamgar Parsi and Behrooz Kamgar-Parsi*

AIT-93-008 Applying Monte Carlo Methods On The Connection Machine To Simulate Photon Propagation In the Ocean, *Jerry L. Gorline*

AIT-93-009 Radar Modeling For Strike Warfare Decision Aids, *Miguel R. Zuniga, Jeffrey K. Uhlmann andJames B. Hofmann*

AIT-93-010 Application of the Hough Transform to Broadband Multipath Interference Patterns for Passive Detection, *Richard Stevens andWilliam Smith*

AIT-93-011 Application of the Hough Transform to Acoustic Broadband Correlograms for Passive Detection and Location, *Richard Stevens and Howard Shyu*

AIT-93-012 The Advanced Processor Technology Testbed, *Wendell L. Anderson and William R. Smith*

AIT-93-013 An Overview of the Processing Graph Support Environment, *Roger Hillson*

AIT-93-014 Computation of Acoustic Fields on a Massively Parallel Processor Using Lattice Gas Method, *S. K. Numrich, R. A. Krutar and R. Squier*

VII. CENTER FOR COMPUTATIONAL SCIENCE

CODE 5590

The Center for Computational Science (CCS), Code 5590, conducts research and development to further the advancement of computing and communications systems to solve Navy problems. The Branch accomplishes this mission through a balanced focus on service, research, and development. The Center is committed to investigating and developing leading edge technologies to establish an advanced computational environment that will benefit all research areas. The Branch studies new technologies to evaluate their potential. Promising technologies are further developed, enhanced, and transitioned to production systems. The Branch's operational efforts provide for a computing environment that emphasizes reliability, high performance, and user productivity. In the area of research and development the Branch develops and implements new technologies, both hardware and software, to solve Navy problems in diverse application areas. Current thrusts include: parallel and distributed hardware, software and display technologies; signal processing techniques directed toward exploitation of massively parallel systems; development of hardware architecture independent systems for developing and porting code for parallel processing; and development of high-speed networks.

In the area of operational support, the Center provides shared high performance computing and networking resources and related services, including user support and training, for NRL, Navy, and DoD interdisciplinary research efforts. The Branch manages and operates NRL's shared massively parallel supercomputer, vector mini-supercomputer, central file server/archiver, and scientific visualization systems. The Branch has responsibility for the laboratory's local area network and external connections to network and computer systems world-wide. The Branch also provides laboratory ADP logistic support by identifying ADP requirements and securing and administering contractual support for lab-wide or multiple buys of ADP systems, software and services.

Title: An Application for Visualizing Molecular Dynamics Data Developed Under AVS/Express

Author: Upul R. Obeysekare and Chas J. Williams

Citation: AVS95 Conference Proceedings

Date: April 1995

Report No.: CCS-95-001

Abstract

We discuss issues related to developing an application for visualizing data from molecular dynamics simulations. The application was developed using visual programming and user-interface design features available in the application development environment of AVS/Express. A suite of AVS5 modules (reported in AVS'94) is being converted to AVS/Express objects that use AVS/Express's new field data scheme. Details related to defining spheres to represent atoms under the new field data scheme are discussed. Important features for molecular dynamics visualization applications such as picking and highlighting atoms are being tested using the new architecture of AVS/Express. Methods for implementing multiple data readers within the same AVS/Express application are also addressed.

Title: CM-5 Kernel Optimization of a Global Weather Model,

Author: P.B. Anderson, D.W. Norton, and M.A. Young

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Citation: Naval Research Laboratory Memorandum Report, NRL/MR/5593--95-7755

Date: July 7, 1995

Report No.: CCS-95-002

Abstract

This report documents the results of optimizing the computational kernel of the National Meteorological Center (NMC) weather forecasting model running on the Thinking Machine Corporation CM-5. The baseline for this optimization work is a basic version of the kernel which runs on both the CM-5 and CM-200. An optimized version for the CM-5 is produced and its performance is compared with the basic version on both CM-5 and CM-200 as well as the best-performing CM-200 version.

1994 PUBLICATIONS

CCS-94-001 On Commonalities In Signal Design for Non-Gaussian Channels, *Nhi-Anh Chu*

CCS-94-002 Visualizing Time Dependent Data From Molecular Dynamics Simulations Using AVS, *Upul R. Obeysekare, Chas J. Williams and Robert O. Rosenberg*

CCS-94-003 Real-Time Visual Control of Numerical Simulations, *U.R. Obeysekare, F.F. Grinstein, Chas J. Williams, and G. Patnaik*

CCS-94-004 Connection Machine Software Conversion of the Navy TOPS Model, *Paul B. Anderson and Michael A.Young*

1993 PUBLICATIONS

CCS-93-001 ADP Contract Consolidation...Does It Compute?, *John L. Douglas*